

How do people get information for COVID-19 according to age groups?

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Abstract

This study highlights how people get important information on COVID-19 according to age groups by employing social network analysis for Twitter. First, people have different key players according to the age groups. For example, while universities and journals play a crucial role in the adults' networks, news media have a significant impact on the elderly's networks. Second, people have different characteristics of social network groups according to age. For example, people belong to small groups, and barely communicate with others across the groups in the teens' networks, whereas people in each group have strong communication networks with other groups in the elderly's networks. Third, this study shows that people utilise different domains to share COVID-19 information according to age. For example, while twitter.com ranks first in the children, teens, and elderly's networks, cnn.com places first in the adults' networks.

KEYWORDS

age, coronavirus, COVID-19, social network analysis, twitter

Highlights

- People have different key players according to age
- People have different characteristics of social network groups according to age
- People utilise different domains to share COVID-19 information according to age
- Governments and policymakers should understand the characteristics of social networks for COVID-19 according to age

1 | Introduction

Coronavirus (COVID-19) has been one of the most important issues across the world (see e.g.,¹⁻⁵). As of 18 June 2020, according to the Johns Hopkins Coronavirus Resource Centre, more than 8.28 million cases have been reported across 188 countries, resulting in more than 446,000 deaths. COVID-19 is considered as one of the worst viruses in human history since it has a dominant contagious disease and infection fatality rate.

COVID-19 also exerts a significant impact on global mental health and plays a different role in the psychological status across countries. For example, Wang et al.⁶ report that Poland and the Philippines experience the highest levels of anxiety, depression and stress, whereas Vietnam has the lowest mean scores in these areas among eight countries (China, Poland, the Philippines, Spain, the US, Iran, Pakistan, and Vietnam). Wang et al.⁷ highlight that Thailand shows all the highest scores of stress, anxiety, and depression scores, while Vietnam exhibits all the lowest scores among seven countries in Asia (China, Iran, Malaysia, Pakistan, Philippines, Thailand, and Vietnam).

Most countries and policy makers have developed many disease policies to control the COVID-19 pandemic, such as lockdown, social distancing, face mask use, hand hygiene, training, and workplace safety (see e.g.,⁸⁻¹⁸). For example, Le et al.¹⁰ report that Vietnam implements a partial lockdown on 1 April 2020 where residents are able to go outside only for essential needs and have to stay at home. Tan et al.¹⁵ show that the Chinese government implements lockdown and quarantine on Chongqing to control the COVID-19 epidemic, and all workers are forced to cease working from 31 January 2020 to 9 February 2020.

Governments and organisations have discovered that COVID-19 exerts a different impact on people according to their age (see e.g.,¹⁹⁻²³). For instance, the Centres for Disease Control and Prevention (CDC; 2021), as of 18 June 2020, 93% of COVID-19 death occur are reported in the population over 55 years of age. European Commission²⁴ reports that 94% of fatalities are uniformly concentrated in the population over 60 years of age, and the case fatality rate (CFR) for all countries is starting to increase after age 50.

Scholars have also explored how COVID-19 plays a significant role in people and information dissemination tools by employing Social Network Services (SNS) and Social Network Analysis (SNA; see e.g.,²⁵⁻²⁸). This is because SNS and SNA are some of the most important data sources and visualisation methodologies for information dissemination in our knowledge-based society and are utilised in many academic fields, such as medicine, urban planning, business, engineering, and so on.

For instance, Kuchler et al.²⁶ exhibit that COVID-19 is more likely to spread between regions with stronger social network connections in Westchester County, NY, in the US and Lodi province in Italy by using aggregated data from Facebook. Li et al.²⁷ show that YouTube has tremendous potential to both support and hinder public health efforts for COVID-19 from the top 75 viewed videos. Block et al.²⁵ highlight that a strategic social network-based reduction of contact significantly improves the effect of social distancing measures by adopting a social network approach. Nielsen et al.²⁸ report that superspreading sharply increases mitigations that reduce the overall personal contact number and that social clustering enhances this effect using a mathematical social network model.

However, prior studies have barely highlighted how people get important information for COVID-19 according to the age. Understanding communication networks is necessary to provide valuable information on COVID-19 for people to minimise the virus damage in a timely manner. For instance, children are highly interested in protecting themselves from coronavirus in the school environment, and the elderly care more about COVID-19 since they are the most susceptible to the virus because of their health conditions, such as cardiovascular diseases, respiratory diseases, or diabetes.

Therefore, this study aims to highlight how people communicate with others to share valuable information on COVID-19 according to the age groups (children, teens, adults, and elderly) by employing SNA based on Twitter, which is one of the most popular SNS. To the best of my knowledge, this study is the first article exploring the social networks for COVID-19 according to the age by employing SNA for SNS.

2 | LITERATURE REVIEW

COVID-19 is a new disease linked to the same type of coronaviruses, such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS). Symptoms can include cough, fever, and shortness of breath. In some cases, the infection can cause pneumonia or breathing difficulties. More rarely, the disease can be fatal. COVID-19 can be transmitted not only through direct contact with respiratory droplets of an infected person, but also be infected from touching surfaces contaminated with the virus and touching their face.²⁹ Many countries have put in place lockdowns and public health measures to promote physical distancing, good hand hygiene and isolating cases and testing, and tracing of contacts of people with COVID-19.³⁰

Countries have found that COVID-19 differently affects people according to the age. For example, Korea Centres for Disease Control and Prevention³¹ reports that severe cases of COVID-19 according to age groups as follows: children (0%), teens (0%), adults (25.0%), and elderly (75.0%) as of 18 June 2020. The Office for National Statistics³² in the UK shows the COVID-19 deaths according to age groups as follows: 0–15 years (0.0%), 15–44 years (1.1%), 45–64 years (9.7%), and 65+ years old (89.2%). The New York City Health³³ shows that the COVID 19 deaths of people are differentiated by the age as of 13 May 2020 as follows: 0–17 years old (0.06%), 14–44 years old (3.9%), 45–64 years old (22.4%), 65–74 years old (24.9%), and 75+ years old (48.7%).

Scholars also have highlighted the relationship between COVID-19 and age groups. Cortis³⁴ show that COVID-19 tends to have higher morbidity in younger individuals but higher mortality for the elderly, and the percentage of children and teens under 14 with confirmed COVID-19 cases is far lower than the standard population percentage. Davies et al.³⁵ highlight that susceptibility to COVID-19 in children of age is approximately half that of adults and elderly, and that clinical symptoms manifest in 21% of infections in teens, rising to 69% of infections in elderly over 70 years based on South Korea, China, Italy, Japan, Singapore, and Canada. Verity et al.³⁶ highlight that the death rate of covid-19 has been calculated at 0.66%, rising drastically to 7.8% in people aged over 80 and declining to 0.0016% in children aged 9 and under based on the data of patients who died from COVID-19 in Hubei, mainland China and 37 countries, as well as Hong Kong and Macau.

Some scholars have focussed on how COVID-19 plays an important role in psychological health according to age groups (see e.g.,³⁸). For instance, Tee et al.³⁷ report that the young age group of 12–21.4 years has significantly high stress, anxiety, and depression based on online surveys of 1879 participants gathered from March 28–12 April 2020. Wang et al.¹⁸ exhibit levels of psychological impact, anxiety, depression, and stress during the initial stage of the COVID-19 outbreak using an online survey of 1210 respondents from 194 cities in China from January 31 to 2 February 2020. Wang et al.³⁹ report mental health of the general population during the COVID-19 pandemic for Iran and China based on 1411 respondents (550 from Iran and 861 from China).

As prior studies indicate, most articles have focussed on the age distribution of COVID-19 deaths or psychological impacts across countries. In other words, the social networks of people to cope with COVID-19 according to age groups have not highlighted in the literature. Therefore, this study explores how people communicate with others to cope with the COVID-19 pandemic according to age groups by employing SNA for Twitter.

3 | RESEARCH METHODOLOGY

This study employs SNA to show the communication networks for COVID-19 according to the age. SNA is a methodology of representing networks of individuals as graphs to show edges among nodes (see e.g.,⁴⁰). Scholars employ SNA to demonstrate the relationship among individuals for their research topic (see e.g.,^{41–45}). This study utilises Twitter data to demonstrate social networks of people for COVID-19 across age groups. Twitter has been widely employed for big data analyses in the academic field (see e.g.,^{46–50}). This study observes Twitter data stream between May 26 and 2 June 2020 based on the keywords COVID-19 and the age group and chooses the best data set for the analyses (May 27 and May 28) based on some important criteria (e.g., the number of Twitter users, communications,

and suitable contents). This study selects key players in the following categories: doctors, institutes, news media, organisations, politicians, professors, activists, journals, universities, researchers, and others.

This study employs NodeXL to highlight social networks of COVID-19 across the age groups. NodeXL is a visualisation software programme, which supports social networks and content analysis. NodeXL has been extensively employed as a social network methodology in academic fields (see e.g.,⁵¹). This study utilises PageRank (PR) to highlight the magnitude of the importance of public key players. PageRank measures the importance of each vertex within the graph using a link analysis algorithm developed by Larry Page who is one of the co-founders of Google along with Sergey Brin (see Table 1 for descriptive statistics).

4 | RESULTS

Tables 2–5 demonstrate the social networks for COVID-19 according to the age groups. In the children's networks, doctors play the most important role in social networks for COVID-19. For instance, Amalina who is a general surgeon in London ranks first, and Zoë Hyde who is a doctor at the University of Western Medical School places second. Also, Kerryn Phelps who is one of Australia's best-known doctors takes ninth. Next, Organisations play the second important role in the networks among top key players. For example, UNICEF, World Health Organisation, and WHO African Region place third, fourth, and fifth, respectively. Not only them, but also UN Human Rights ranks eighth, and Amer Acad Paediatrics, which is the American Academy of Paediatrics dedicated to the health of all children, takes fourteenth.

In the teens' networks, organisations play the most significant role in social networks for COVID-19. For example, organisations rank first, third, and fifth. To be specific, the American Psychological Association, which is the largest

TABLE 1 Descriptive statistics

Graph metric	Children	Teens	Adults	Elderly
Graph-type	Directed	Directed	Directed	Directed
Vertices	18,064	1496	16,563	17,297
Unique edges	30,629	2083	17,977	25,131
Edges with duplicates	4183	175	5287	1992
Total edges	34,812	2258	23,264	27,123
Self-loops	1840	297	1193	2053
Reciprocated vertex pair ratio	0.008	0.029	0.010	0.010
Reciprocated edge ratio	0.016	0.057	0.020	0.020
Connected components	1751	391	1300	2189
Single-vertex connected components	652	155	541	904
Maximum vertices in a connected component	12,040	73	12,592	10,135
Maximum edges in a connected component	26,783	318	18,079	18,372
Maximum geodesic distance (diameter)	23	6	19	25
Average geodesic distance	6.040	1.911	4.545	6.831
Graph density	0.000	0.001	0.000	0.000
Modularity	0.833	0.848	0.784	0.878
Minimum PageRank	0.222	0.292	0.260	0.221
Maximum PageRank	750	22	1843	335
Average PageRank	1	1	1	1
Median PageRank	0.549	0.749	0.529	0.573

TABLE 2 Top 20 key players in children

No	PR	Name	Description
1	D1	750.3 Amalina	Doctor of Medicine in London
2	D2	510.8 Zoë Hyde	Doctor at the University of Western Medical School
3	O1	170.2 UNICEF	Humanitarian Aid Organisation
4	O2	130.0 WHO	World Health Organisation
5	O3	120.0 WHO African Region	WHO African
6	P1	95.2 Scott Morrison	The Prime Minister of Australia
7	T1	85.2 Melinda Gates	American Philanthropist Co-founded the Bill & Melinda Gates Foundation
8	O4	76.2 UN Human Rights	Organisation for Human Right
9	D3	75.8 Kerryn Phelps	One of Australia's Best-Known Doctors
10	P2	54.0 Justin Trudeau	Prime Minister of Canada
11	R1	52.8 Henrietta H. Fore	Executive Director of UNICEF
12	A1	45.9 Agnes Callamard	Human Rights Activist
13	P3	37.1 Greg Abbott	Governor of Texas
14	O5	34.4 Amer Acad Paediatrics	The American Academy of Paediatrics for the Health of all Children.
15	F1	33.5 Azra Ghani	Professor of Infectious Disease Epidemiology at Imperial College London
16	N1	29.2 RT	Russian International Television Network
17	R2	27.8 Tedros Adhanom Ghebreyes	Director General of the World Health Organisation
18	P4	26.9 Gary Gannon	Irish Social Democrats Politician
19	P5	26.1 SAnna Marin	Prime Minister of Finland
20	P6	25.9 Hanna Kosonen	Minister of Science and Culture in Finland

Abbreviations: Activists, A; D, Doctors; Professor, F; Institute, I; Journals, J; News media, N; Organisation, O; Politicians, P; PR, PageRank; R, Researcher; T, other; U, Universities.

scientific and professional organisation of psychologists in the United States, ranks first. The MentalHealthFirstAid, which is the national programme to teach the skills to respond to the signs of mental illness and substance use, ranks third. The HealthyChildren, which is the official parenting website of the American Academy of Paediatrics, takes fifth. Not only that, but also 11 out of the top 20 key players are organisations, which are 55% of the key players.

In the adults' networks, people show some unique characteristics of social networks for COVID-19. They have two key player groups (universities and journals), which are not in the other networks. First, Universities play a crucial role in communication networks. For example, UC San Francisco, which is the University of California, San Francisco, ranks second, and RoyalCollegeObsGyn, which is the Royal College of Obstetricians and Gynaecologists, places sixth. HarvardPublicHealth, which is the public health school of Harvard University, and CCDD at Harvard Chan, which is the Centre for Communicable Disease Dynamics at Harvard, rank 19th and twentieth, respectively. Second, Microbes & Infection, which is the journal covering all fields of infection & immunity, places eleventh, and JAMA, which is the Journal of the American Medical Association, ranks seventeenth. Another characteristic of adults is that people rely on institutes higher than others. For example, the Centres for Disease Control and Prevention ranks first.

In the elderly's networks, people tend to rely on the key players that allow people to access easily, inconsistent with adults. For example, news media play an important role in elderly, whereas they have no top 20 key players in adults. The QuickTake by Bloomberg, which is the global news the world needs today, ranks second, and the OffGuardian, which is the independent news and opinion website, places fourth. The BBC Radio 4 Today, which is the BBC's long-running early morning news, places ninth, and the Science News, which is the American bi-weekly

TABLE 3 Top 20 key players in teens

No	PR	Name	Description	
1	O1	21.5	American Psychological Association	The Largest Organisation of Psychologists in the US
2	I1	13.0	Indiana State Department of Health	The Indiana State Department of Health
3	O2	12.2	MentalHealthFirstAid	National Programme for Mental Illness and Substance Use
4	I2	10.8	Ottawa public health	Ottawa's Health Information, Programs & Services
5	O3	8.9	Healthychildren	Official Parenting Website of the American Academy of Paediatrics
6	F1	6.2	Miranda van Tilburg	Professor of Clinical Research at Campbell Univeristy
7	A1	6.2	Mandy Sanghera	International Human Rights Activist
8	O4	4.4	Bullying UK	UK Charity
9	N1	4.0	SchoolLibraryJournal	American Monthly Magazine for Young People
10	O5	3.9	JED	Organisation for Teens and Young Adults
11	O6	3.9	Human Rights Campaign	The Largest LGBTQ Advocacy Group
12	O7	3.6	Junior Achievement	Global Non-Profit Youth Organisation
13	O8	3.5	Minding Your Mind	Organisation for Ending Stigma and Destructive Behaviours Associated With Mental Health Issues
14	N2	3.4	CNBC	The World Leader in Business NEWS
15	A2	3.0	Jamie Margolin	American Climate Justice Activist
16	O9	2.9	NAGC	Promotes Awareness of the Needs of Children and Teens
17	O10	2.9	C. Elizabeth Dougherty	Organisation for Supporting Children, Youth and Adults Facing Complex Illness
18	O11	2.7	NCMEC	National Centre for Missing and Exploited Children
19	N3	2.6	news.com.au	Australia's #1 News Site
20	N4	2.6	Local 12/WKRC-TV	Cincinnati's Trusted Source for Breaking News

magazine, ranks sixteenth. Also, Facebook, which is one of the most popular and easily accessible social media platform, ranks twelfth. Another interesting character is that Donald Trump, the US president, ranks eleventh. They are the only networks, which have Donald Trump as the top key player.

Figure 1 shows the communication networks of people based on PR. In the children's networks, most key players are highly concentrated in the central part of the circle. Some key players, such as Azra Ghani (F1), Justin Trudeau (P2), Azra Ghani (P3), and Amalina (D1), relatively have some distances from other key players. In the teens' networks, people show relatively dispersed patterns. Overall, key players are located in the central part of the networks. In the adults' networks, nodes are highly concentrated in some parts, and key players show the most dispersed locations among all networks. The Centres for Disease Control and Prevention (I1), HHS.gov (I3), and JAMA (J2) are placed in the central part of the networks. In the elderly's networks, nodes show a large circle, and most key players are located in the large networks. Some key players, such as Donald Trump (P3) and Zaem Zia (R2), play an important role in outer networks of the circle.

Next, this study employs cluster analysis by utilising the Clauset–Newman–Moore cluster algorithm. Cluster analysis is a methodology for the task of assigning a set of objects into groups so that the objects in the same cluster are more similar to each other than those in other clusters. The Clauset–Newman–Moore cluster algorithm is one of the best methods for big data analysis.⁵² Figures 2 and 3 show the social networks according to age groups based on the Clauset–Newman–Moore cluster algorithm. In the children's networks, Amalina (D1) and Zoë Hyde (D2) are located in the centre of group 1 and group 3, respectively (see Figure 5). UNICEF (O1), World Health Organisation

TABLE 4 Top 20 key players in adults

No	PR	Name	Description	
1	I1	1842.8	CDC	The Centres For Disease Control And Prevention
2	U1	162.7	UC san Francisco	The University of California, San Francisco
3	D1	132.8	Dena Grayson	American Medical Doctor
4	R1	73.5	Eric Feigl-ding	American Public Health Scientist
5	F1	60.3	Mehmet Oz	Columbia University professor
6	U2	60.2	RoyalCollegeObsGyn	The Royal College of Obstetricians and Gynaecologists
7	O1	47.1	WHO	World Health Organisation
8	O2	39.8	Sport England	Non-Departmental Public Body
9	O3	38.8	WHO South-East Asia	WHO South-East Asia
10	O4	34.5	The RCM	British Midwives Organisation
11	J1	30.2	Microbes & Infection	Journal for Infection & Immunity
12	P1	29.9	John Cornyn	United States Senator
13	I2	26.3	Health Canada and PHAC	Agency of the Government of Canada for Public Health
14	F2	24.3	Zoë Hyde	Faculty at the University of Western Medical School
15	O5	18.8	WHO African Region	WHO African Region
16	P2	18.7	Steve Herman	America's White House Bureau Chief
17	J2	16.6	JAMA	The Journal of the American Medical Association
18	I3	15.3	HHS.gov	United States Department of Health and Human Services
19	U3	14.4	HarvardPublicHealth	Public health School of Harvard University
20	U4	14.4	CCDD at Harvard Chan	The Centre for Communicable Disease Dynamics at Harvard

(O2), and Henrietta H. Fore (R1) play an essential role in group 2. While group 1 tends to communicate with others within the group, group 2 and group 3 actively communicate with other groups.

In the teens' networks, Mandy Sanghera (A1), the American Psychological Association (O1), and the Ottawa Public Health (I2) play the central role in group 1, group 2, and group 4, respectively. People belong to small groups, and rarely communicate with others across the groups. All key players have an independent group except for the Junior Achievement (O7) and CNBC (N2; group 12) and NAGC (O9) and C. Elizabeth Dougherty (O10; group 17).

In the adults' networks, people are heavily concentrated in group 1 and group 2, and they actively communicate with other groups. While I1 plays the crucial role in group 1, there is no key player in group 2. Many key players (13 out of 20) have their independent group, whereas the rest key players play an important role in small groups.

In the elderly's networks, people are relatively distributed in each group. Each group has strong communication networks with other groups. They show the most open communication systems across the groups. QuickTake by Bloomberg (N1) and the Centres for Disease Control and Prevention (I1) are located in the central hubs of group 1. The Code of Vets (O3) and Andrew Cuomo (P1) play an important role in group 2. The BlueSky (R1) and Donald Trump (P3) exert an important impact on group 3 and group 4, respectively.

Table 6 show that people utilise different domains to share COVID-19 information according to the age. In the children's networks, twitter.com ranks first. Gofundme.com, which is the American crowdfunding platform that allows people to raise money for events ranging from life events, such as celebrations and graduations to challenging circumstances like accidents and illnesses, ranks second. Techfordaddy.com places third since many parents are in sympathy with the article in the parenting category, that is, toddlers cannot understand why they must do social distancing, but they would understand their parents' efforts 1 day. Co.uk, which is the Internet country code top-level domain for the United Kingdom, ranks fourth, and com.au, which is the Internet country code top-level domain for Australia places fifth. In the teen's networks, twitter.com places first. Slj.com, which is the School Library Journal of

TABLE 5 Top 20 key players in elderly

No	PR	Name	Description	
1	R1	335.1	BlueSky	Researcher IT Consultant/Software Engineer
2	N1	165.7	QuickTake by bloomberg	Global News the World Needs Today
3	I1	161.8	CDC	Centres for Disease Control and Prevention
4	N2	111.6	OffGuardian	Independent News and Opinion Website
5	F1	106.2	Christian Christensen	Professor of Journalism at Stockholm Univ
6	P1	86.1	Andrew Cuomo	Governor of New York
7	F2	69.6	Jane Philpott	Dean of the Queen's University Faculty of Health Sciences
8	O1	61.1	World Economic Forum	Organisation for Improving the State of the World
9	N3	53.8	BBC Radio 4 Today	BBC's long-running early morning news
10	P2	53.0	Helen Whately	British conservative party politician who was appointed Minister of State at the Department of Health and Social Care
11	P3	41.8	Donald J. Trump	The US President
12	T1	39.7	Facebook	Social Media Company
13	R2	34.9	Zaeem Zia	Director Health Information Systems GB/District Health Officer
14	P3	31.1	Yediyurappa	Chief Minister of Karnataka
15	O2	30.1	Workers party of Britain	Organisation for workers Party of Britain
16	N4	27.4	Science News	American Bi-Weekly Magazine
17	O3	26.6	Code of Vets™	Organisation Dedicated to Assisting America's Veterans.
18	P4	26.3	David Vance	American Politician
19	A1	23.4	Shaun King	American Writer, Civil Rights Activist
20	A2	22.5	Vanessa Beeley	British Activist and Blogger

the American monthly magazine for young people, ranks second. Youtube.com takes third, and co.uk places fourth. Npr.org, which is the National Public Radio, takes fifth.

In the adults' networks, cnn.com places first, inconsistent with other groups' networks. Twitter ranks second, and official domains take from third to fifth. For example, cdc.gov, which is the Centres for Disease Control and Prevention of the United States, ranks third. co.uk and org.uk place fourth and fifth, respectively. In the elderly's networks, twitter.com places first, followed by weforum.org, cbc.ca, co.uk, and youtube.com. weforum.org is the world economic forum that engages the foremost political, business, cultural and other leaders of society to shape global, regional and industry agendas. Cbc.ca is the Canadian Broadcasting Corporation that serves as the national public broadcaster for both radio and television.

5 | DISCUSSION

COVID-19 has been one of the most important issues across the world. Understanding COVID-19 has become one of the most essential tasks for governments, scholars, urban planners, health planners, policymakers, and so on. This study highlights how people get important information for COVID-19 according to age groups.

This study finds some significant results, consistent (or inconsistent) with prior studies. First, this study finds that people show significant differences among age groups for COVID-19, consistent with the finding of the prior study (see e.g.,^{34,35,53,54}; Tee et al., 2020). The results may be because younger people are more familiar with SNS to express their opinions for COVID-19. For example, Klaiber et al.⁵³ reveal that younger people show more concerns

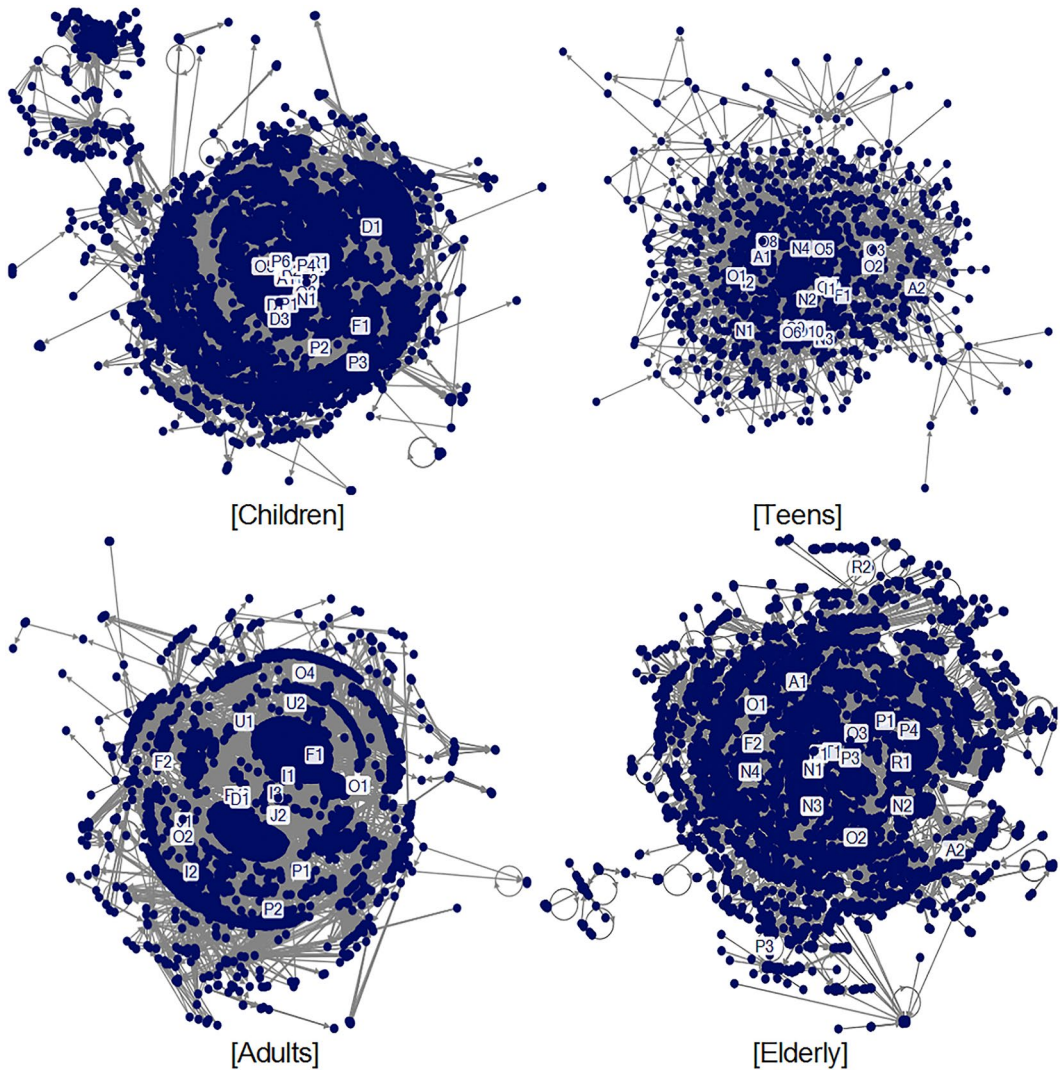


FIGURE 1 PageRank [Colour figure can be viewed at wileyonlinelibrary.com]

about the threat of COVID-19 across multiple domains, such as popular print, television, and radio news outlets in North America.

Second, this study finds that people develop different social networks according to their groups, consistent with prior studies (see e.g.,⁵⁵⁻⁵⁷). For example, Gauthier et al.⁵⁵ highlight that older minority people may experience the most severe effects of COVID-19 since they are more apt to be isolated and have smaller networks.

Third, this study suggests that SNS play an important role in sharing and providing useful information for COVID-19 to people, consistent with prior literature (see e.g.,^{26,27,58}). For instance, Li et al.⁵⁸ show that Chinese people express higher negative emotions, such as anxiety, depression, and indignation, and sensitivity to social risks on Weibo in the same group before and after the declaration of COVID-19 on 20 January, 2020.

This study has some limitations as follows: first, this study explores the social networks of COVID-19 according to the age groups based on cross-sectional data. The findings may be different in a longitudinal study. The longitudinal change of people for COVID-19 would play an important role in understanding the pandemic.⁵⁹ Future research should highlight the changes of social networks for COVID-19 by employing the longitudinal methodology.

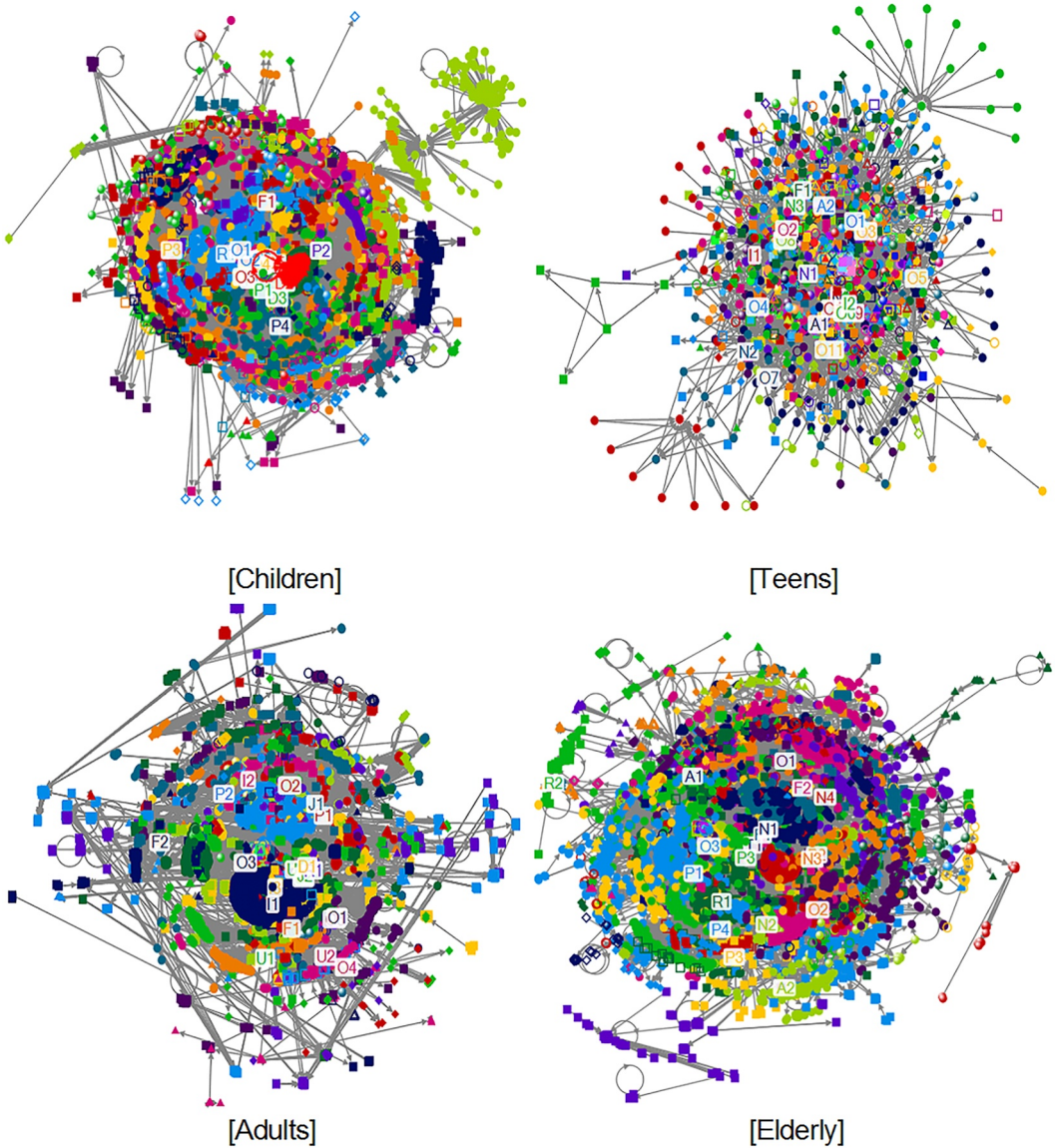


FIGURE 2 Social networks for the typical case [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

Second, while there was no vaccine for COVID-19 at the study period, new COVID-19 vaccines have been developed across the world. More than 50 vaccines for COVID-19 are either undergoing clinical trials or already approved in many countries.⁶⁰ Therefore, vaccines would exert a significant impact on social networks. Future articles should highlight the effects of vaccines on social networks for COVID-19 according to age groups.

Third, this study highlights how people build their social networks for COVID-19 by exploring only Twitter. Therefore, Other SNS, such as Facebook or YouTube, may show different results for the age groups. Future studies should investigate the social networks of age groups according to a multitude of social media.

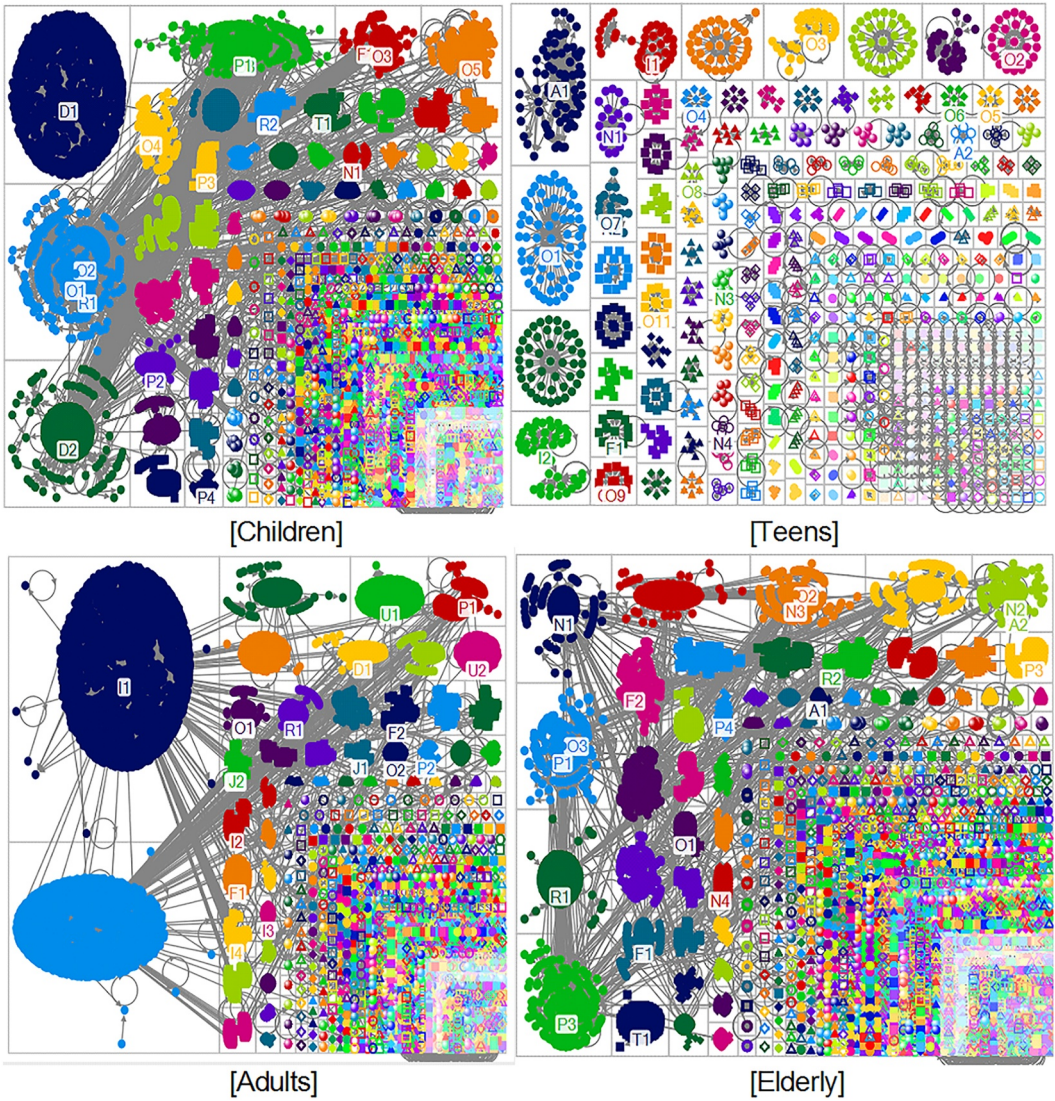


FIGURE 3 Social networks for groups [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 6 Top five domains in the networks

Children		Teens		Adults		Elderly		
Domains	Count	Domains	Count	Domains	Count	Domains	Count	
1	twitter.com	362	twitter.com	45	cnn.com	235	twitter.com	393
2	gofundme.com	105	slj.com	20	twitter.com	227	weforum.org	173
3	techfordaddy.com	80	youtube.com	15	cdc.gov	39	cbc.ca	82
4	co.uk	74	co.uk	11	co.uk	34	co.uk	59
5	com.au	57	npr.org	11	org.uk	27	youtube.com	54

6 | CONCLUSIONS

The COVID-19 situation has been worse as time passes. Understanding social networks of people to spread valuable information on COVID-19 would be one of the best ways to control the COVID-19 pandemic. This study highlights how people interact with each other for the COVID-19 to allow governments and scholars to provide useful information to the public according to age groups since the virus exerts a different impact on people by age.

This study finds some outstanding results as follows: first, people have different key players according to the age groups. For example, doctors play the most important role in children's networks for COVID-19. Organisations play the most significant role in teens' networks. Universities and journals play a crucial role in adults' networks. News media have a significant impact on elderly's networks.

Second, people have different characteristics of social network groups according to the age. For example, in the children's networks, while group 1 tends to communicate with others within the group, group 2 and group 3 actively communicate with other groups. In the teens' networks, people belong to small groups, and barely communicate with others across the groups. In the adults' networks, group 1 and group 2 actively communicate with other groups. In the elderly's networks, people are relatively distributed in each group, and each group has strong communication networks with other groups.

Third, this study shows that people utilise different domains to share COVID-19 information according to the age. For example, while twitter.com ranks first in the children, teens, and elderly's networks, cnn.com places first in the adults' networks. In contrast, co.uk takes fourth in all groups' networks. On the other hand, some domains for specific age groups rank high in the group networks. For instance, Techfordaddy.com, which provides useful parenting information for fathers, ranks third in the children's networks, and slj.com, which covers a wide variety of topics with a focus on technology, multimedia, and other information resources that arouse the interest of young learners in school, places second in the teens' networks.

This study suggests some important implications as follows: first, governments and policymakers should understand the characteristics of key players according to the age. For example, in the adults' networks, people are highly interested in information on COVID-19 from universities and journals, whereas they barely care about news media. In contrast, in the elderly's networks, they show the opposite characteristics of adults. Therefore, governments and policymakers should provide important information and useful data sources according to their characteristics.

Second, governments and centres for disease control and prevention should investigate the group networks of communications for COVID-19 according to age groups since people show different patterns for social networks based on their age. For instance, teens show relatively closed network systems, whereas the elderly exhibit relatively open network systems.

Third, governments and policy practitioners should explore how people utilise Internet websites to get access to COVID-19 information according to age groups. Not only young people, but also old people actively use social network systems, such as Twitter, Facebook, and Instagram, in our knowledge-based societies. This study finds people use different websites to get COVID-19 news based on their age, and it would be an excellent way to release relevant information on COVID-19 via important websites of the age groups.

Lastly, this study contributes to the theory as follows: to the best of my knowledge, there is no known information about social networks for COVID-19 according to a multitude of age groups by employing SNA for SNS. Methodological analyses of this study would contribute to develop theoretical models based on SNS (see e.g.,^{61,62}). This study would shed new light on how people communicate with each other for the COVID-19 pandemic according to age groups, which contributes to theory and literature in health communication and social network research. For example, the findings of this article could contribute to information and health literature, such as improving theoretical coverage, reducing methodological biases, strengthening causality linkages, reducing interference of noise, improving validity and reliability of models, and developing theory that works well within limitations (see e.g.,^{63,64}).

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ETHICS STATEMENT

Not applicable.

DATA AVAILABILITY STATEMENT

Data is available upon reasonable requests.

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