MAYO CLINIC

Status of Acute Myocardial Infarction in Southern India During COVID-19 Lockdown: A Multicentric Study

Ramachandran Meenakshisundaram, MBBS, MRCP, PhD, PGCert in HBE, FHEA;
Subramanian Senthilkumaran, MD, PhD;
Ponniah Thirumalaikolundusubramanian, MD; Melvin Joy, MSc;
Narendra Nath Jena, MD; Ramalingam Vadivelu, MD; Shyamsundar Ayyasamy, MD;
and V.P. Chandrasekaran, MD

Abstract

There has been a reduction in the reported cases of acute myocardial infarction (MI) across the globe during the outbreak of coronavirus disease 2019 (COVID-19) (severe acute respiratory distress syndrome coronavirus 2). An attempt was made to find out the number of acute MI cases treated during the COVID-19 lockdown period (April 2020) and highlight the possible reasons for the changes in the occurrence. A multicentric retrospective observational study was performed to collect the selected data from 12 private hospitals distributed in 4 cities—Madurai, Trichy (Thiruchirapalli), Erode, and Salem—of the Tamil Nadu state in southern India. There was a significant ($P<.001$) reduction in ST-segment elevation MI (STEMI), non-STEMI (NSTEMI), and total (STEMI and NSTEMI together) cases during the lockdown period (April 1 to 30, 2020) as compared with no-lockdown periods such as January and February 2020 and April 2019 and April 2018 in all cities, whereas the reduction was not significant for NSTEMI in Trichy when data for the lockdown period was compared with those for January and February 2020. Overall, there is a reduction in acute MI cases, which may be due to alterations in modifiable risk factors during the COVID-19 lockdown period. Hence, implementation of public education and polices on controlling modifiable risk factors is likely to pay dividends.

From the Manian Medical Centre, Erode, Tamil Nadu, India (R.M., S.S.); HCA Healthcare UK, HCA International Limited, London, UK (R.M.); Trichy SRM Medical College Hospital and Research Centre, Tiruchirappalli, Tamil Nadu, India (affiliated to the Tamil Nadu Dr. M.G.R. Medical University, Chennai) (P.T.); Christian Medical College, Vellore, Tamil Nadu, India (affiliated to the Tamil Nadu Dr. M.G.R. Medical University, Chennai) (M.J.); Meenakshi Mission Hospital and Research Centre, Madurai, Tamil Nadu, India (N.N.J.); Velammal Medical College Hospital and

Affiliations continued at the end of this article.

Because of the coronavirus disease 2019 (COVID-19) (severe acute respiratory syndrome coronavirus 2) pandemic, strict social containment measures were promoted in the form of lockdown in most of the countries. Although the health system is overwhelmed with COVID-19 cases across the globe, a change in the hospital admission pattern during the lockdown period has been reported.[1-4] The Government of India imposed a nationwide strict lockdown from March 25, 2020, with a nationwide curfew on March 22, 2020.[5] Hence, the present study was conducted to find out the number of acute myocardial infarction (MI) cases, which included ST-segment elevation MI (STEMI) and non-STEMI (NSTEMI) cases, treated during the lockdown period, to compare these cases with those in other months of 2020 before the lockdown as well as with those in the same month of previous years (2018 and 2019), and to highlight the possible reasons for these variations.

PATIENTS AND METHODS

We conducted a multicentric retrospective observational study across 12 private hospitals, which followed similar methods to collect the clinical data and adhere to Good Clinical Practice in the management of acute MI. These hospitals were located in different cities, namely, Madurai, Trichy (Thiruchirapalli), Erode, and Salem in the state of Tamil Nadu in southern India. The data on age, sex, and the category of acute MI (STEMI and NSTEMI) were collected from the records for

TABLE 1. City-wise Cases of Acute Myocardial Infarction and Emergency Department Attendance

Name of the city	No. of hospital(s)	Lockdown period Apr 2020			No-lockdown period											
					2020						Apr 2019			Apr 2018		
					Feb			Jan								
		S	N	ET	S	N	ET	S	N	ET	S	N	ET	S	N	ET
Madurai	2	63	81	1416	155	203	2214	205	239	2786	243	239	2739	238	207	2088
Trichy	1	16	34	385	55	43	478	87	59	489	103	71	438	100	57	417
Erode	4	18	39	765	114	78	638	178	112	694	180	110	687	191	106	701
Salem	5	24	29	865	121	80	738	179	103	732	189	127	810	200	110	798
Total	*12*	*121*	*183*	*3431*	*445*	*404*	*4068*	*649*	*513*	*4701*	*715*	*547*	*4674*	*729*	*480*	*4004*

ET = total number of patients attended the emergency department; N = non— ST-segment elevation myocardial infarction; S = ST-segment elevation myocardial infarction.

January, February, and April 2020 as well as for April 2019 and April 2018. These data were classified as lockdown period (April 2020) and no-lockdown period (January and February 2020 and April 2019 and April 2018). Apart from that, the total number of cases presented to the emergency department of the respective hospitals was collected for the same period. The number of STEMI, NSTEMI, and total (STEMI and NSTEMI) cases treated during the COVID-19 lockdown period (April 2020) was compared with similar cases treated in the no-lockdown period by using the chi-square test. The 95% CI for the difference in proportion was calculated for each. A P value less than .05 was considered statistically significant. The statistical analysis was performed using R software version 4.0.0 (The R Foundation). Data for March 2020 were not considered, as they were a mixture for both no-lockdown and lockdown periods.

RESULTS
The median age of patients admitted during the lockdown and no-lockdown periods was 58 and 53 years, respectively. The sex ratio of male and female was 7:2, and there was no significant difference among them. Details of city-wise cases of acute MI and emergency department attendance are given in Table 1. The overall number of STEMI, NSTEMI, and total (STEMI and NSTEMI) cases treated during the COVID-19 lockdown period (April 2020) was compared with similar cases treated during the no-lockdown period of January and February 2020 and April 2019 and April 2018

independently of each. It was observed that cases treated during the COVID-19 lockdown period were significantly (P<.001) lower than those treated during the no-lockdown period irrespective of the months. The proportion of cases, P value, and 95% CI for the difference in proportion for STEMI, NSTEMI, and total (STEMI and NSTEMI) cases for each city and overall (all cities together) were calculated. The statistical data on acute MI cases treated during the COVID-19 lockdown and no-lockdown periods (city-wise and overall) are given in Table 2. The subanalysis for each city individually for STEMI, NSTEMI, and total cases treated during the COVID-19 lockdown period (April 2020) was significantly (P<.001) lower in Madurai, Erode, and Salem than that during the no-lockdown period. For Trichy, a significant reduction (P<.001) was noticed for STEMI and total cases during the lockdown period compared with the no-lockdown period whereas for NSTEMI cases the reduction was significant for only April 2020 compared with April 2019 and April 2018. When the NSTEMI data for April 2020 were compared with those for January and February 2020, the P value (95% CI) and difference in proportion were 0.153 (0.01 to 0.08) and 0.03 and 1.00 (0.04 to 0.04) and 0.002, respectively. Furthermore, when the statistical analysis was performed with pooled data for all cities for STEMI, NSTEMI, and total, there was a significant reduction in these cases (Table 2). The difference in proportion of acute MI cases treated during the COVID-19 lockdown and no-lockdown periods for each city is depicted in the Figure.

TABLE 2. Statistical Data on Acute Myocardial Infarction Cases Treated During COVID-19 Lockdown and No-Lockdown Periods (City-wise and Overall)

Variable	City name	STEMI				NSTEMI				Total (STEMI and NSTEMI)			
		p1	p2	95% CI	P value	p1	p2	95% CI	P value	p1	p2	95% CI	P value
STEMI (Apr 2020 vs Feb 2020)	Madurai	0.04	0.07	0.01-0.04	.002	0.06	0.09	0.02-0.05	<.001	0.10	0.16	0.04-0.08	<.001
STEMI (Apr 2020 vs Jan 2020)		0.04	0.07	0.01-0.04	<.001	0.06	0.09	0.01-0.05	.001	0.10	0.16	0.04-0.08	<.001
STEMI (Apr 2020 vs Apr 2019)		0.04	0.09	0.03-0.06	<.001	0.06	0.09	0.01-0.05	.001	0.10	0.18	0.05-0.10	<.001
STEMI (Apr 2020 vs Apr 2018)		0.04	0.11	0.05-0.09	<.001	0.06	0.10	0.02-0.06	<.001	0.10	0.21	0.09-0.14	<.001
STEMI (Apr 2020 vs Feb 2020)	Trichy	0.04	0.12	0.04-0.11	<.001	0.09	0.09	0.04-0.04	1.000	0.13	0.21	0.02-0.13	.005
STEMI (Apr 2020 vs Jan 2020)		0.04	0.18	0.09-0.18	<.001	0.09	0.12	0.01-0.08	.153	0.13	0.30	0.11-0.22	<.001
STEMI (Apr 2020 vs Apr 2019)		0.04	0.24	0.15-0.24	<.001	0.09	0.16	0.03-0.12	.002	0.13	0.40	0.21-0.33	<.001
STEMI (Apr 2020 vs Apr 2018)		0.04	0.24	0.15-0.25	<.001	0.09	0.14	0.002-0.09	.041	0.13	0.38	0.19-0.31	<.001
STEMI (Apr 2020 vs Feb 2020)	Erode	0.02	0.18	0.12-0.19	<.001	0.05	0.12	0.04-0.10	<0.001	0.07	0.30	0.18-0.27	<.001
STEMI (Apr 2020 vs Jan 2020)		0.02	0.26	0.20-0.27	<.001	0.05	0.16	0.08-0.14	<.001	0.07	0.42	0.30-0.39	<.001
STEMI (Apr 2020 vs Apr 2019)		0.02	0.26	0.20-0.27	<.001	0.05	0.16	0.08-0.14	<.001	0.07	0.42	0.30-0.39	<.001
STEMI (Apr 2020 vs Apr 2018)		0.02	0.27	0.21-0.28	<.001	0.05	0.15	0.07-0.13	<.001	0.07	0.42	0.31-0.39	<.001
STEMI (Apr 2020 vs Feb 2020)	Salem	0.03	0.16	0.11-0.17	<.001	0.03	0.11	0.05-0.10	<.001	0.06	0.27	0.17-0.25	<.001
STEMI (Apr 2020 vs Jan 2020)		0.03	0.24	0.18-0.25	<.001	0.03	0.14	0.08-0.14	<.001	0.06	0.39	0.28-0.36	<.001
STEMI (Apr 2020 vs Apr 2019)		0.03	0.23	0.17-0.24	<.001	0.03	0.16	0.09-0.15	<.001	0.06	0.39	0.29-0.37	<.001
STEMI (Apr 2020 vs Apr 2018)		0.03	0.25	0.19-0.26	<.001	0.03	0.14	0.08-0.13	<.001	0.06	0.39	0.29-0.37	<.001
STEMI (Apr 2020 vs Feb 2020)	Overall	0.04	0.11	0.06-0.09	<.001	0.05	0.10	0.03-0.06	<.001	0.09	0.21	0.10-0.14	<.001
STEMI (Apr 2020 vs Jan 2020)		0.04	0.14	0.09-0.11	<.001	0.05	0.11	0.04-0.07	<.001	0.09	0.25	0.14-0.17	<.001
STEMI (Apr 2020 vs Apr 2019)		0.04	0.15	0.11-0.13	<.001	0.05	0.12	0.05-0.08	<.001	0.09	0.27	0.17-0.20	<.001
STEMI (Apr 2020 vs Apr 2018)		0.04	0.18	0.13-0.16	<.001	0.05	0.12	0.05-0.08	<.001	0.09	0.30	0.20-0.23	<.001

COVID-19 = coronavirus disease 2019; NSTEMI = non–ST-segment elevation myocardial infarction; Overall = all cities together; p1 = proportion of cases treated during the COVID-19 lockdown period; p2 = proportion of cases treated in the no-lockdown period; STEMI = ST-segment elevation myocardial infarction; CI = confidence interval; Apr = April; Feb = February; Jan = January.

DISCUSSION

Cardiovascular disease is the major cause of mortality and morbidity across the globe. Although the burden of cardiovascular disease has declined in some regions, overall there was no change globally as reported in a multicentric prospective cohort study over the period from 1990 to 2015.[6] Risk factors for cardiovascular disease are already well known. Extreme temperature, change in weather condition, and air pollution have been found to be associated with an increased risk of MI.[7-9] The toxic effect of pollutants has been found to be higher during summer, thereby increasing the risk of cardiopulmonary diseases.[10,11] In Tamil Nadu, this study was conducted in the month of April, which is summer with daytime temperature generally above 30°C and nighttime temperature going down up to 25°C.

During the COVID-19 lockdown period, cases of injuries, infections, illnesses related to behavior, and so on, have reduced in private and government hospitals in the state of Tamil Nadu. In this study, we are limiting to acute MI only. From Table 1, it is clear that the number of cases treated for acute MI was almost consistent during the no-lockdown period of 2020 (January and February) as well as April 2019 and April 2018, whereas it was significantly lower in all the cities during the lockdown period. A similar significant reduction in MI admissions during the lockdown period was noted in recent publications.[1-4] Although the reasons remain unclear, we attribute various factors such as unwillingness to visit hospital owing to fear of COVID-19 infection[4,12]; reduced noise[13] and air pollution,[14,15] reduction in occupational stress in the susceptible population, and avoidance of travel; least or no exposure to tobacco smoke, alcohol, pollution, and junk foods; adherence to relaxation and recreation via audiovisual means, integration with family members, engaging in activities of interest, long hours of
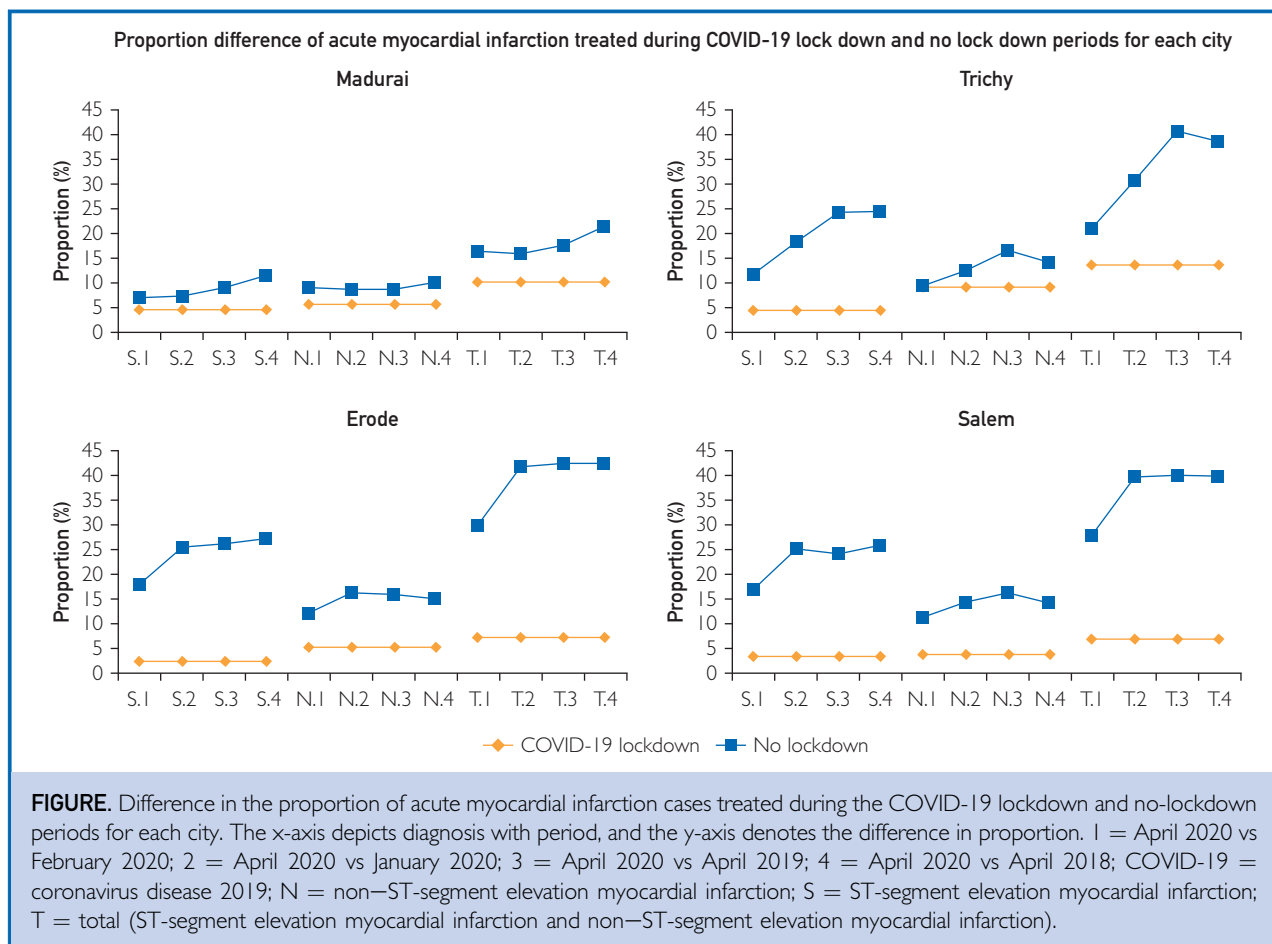
FIGURE. Difference in the proportion of acute myocardial infarction cases treated during the COVID-19 lockdown and no-lockdown periods for each city. The x-axis depicts diagnosis with period, and the y-axis denotes the difference in proportion. 1 = April 2020 vs February 2020; 2 = April 2020 vs January 2020; 3 = April 2020 vs April 2019; 4 = April 2020 vs April 2018; COVID-19 = coronavirus disease 2019; N = non−ST-segment elevation myocardial infarction; S = ST-segment elevation myocardial infarction; T = total (ST-segment elevation myocardial infarction and non−ST-segment elevation myocardial infarction).

sleep, and practicing exercise, yoga, and meditation; limiting to homemade food items, adoption to healthy lifestyle, and overall less physical and mental strain. Moreover, during the lockdown, the pollution index has significantly decreased in India[14] and many other nations,[15] which has a direct relationship with MI.

In summary, the reduction in the number of cases of acute MI during the lockdown period may be due to alterations in modifiable risk factors. Hence, implementation of public education and policies on controlling modifiable risk factors will pay dividends. However, we do not have a city-based registry for acute MI at the moment to state confidently on population-based MI or out-of-hospital deaths due to MI or missed MI due to avoidance of hospital by the public during this COVID-19 pandemic.[1,16] More studies from different cities are warranted to ascertain the changing

epidemiology of illnesses during the pandemic and find out the health advantages of containment activities. During World War II, there was a dramatic reduction in mortality from vascular diseases,[17] which suggested a link for the low occurrence of certain diseases in extraordinary situations such as health crisis or war.

It is the time for the physicians to act in concert with clinical equipoise[18] and find out the reasons for the change in the epidemiology of various illnesses during the COVID-19 outbreak in an unprejudiced manner. These new findings likely pave ways for the prevention of illnesses and find out new methods toward the promotion of health. Also, it is mandatory to educate the public to seek medical attention for worrying symptoms and encourage them for adherence to safety precautions for COVID-19.[19] As the fear of

COVID-19 is a major deterrent for emergency visits, hospitals shall develop community-minded communications[12] to provide risk-free and reassuring environment for patients. The limitations of the study are retrospective and confining to a few selected centers located in a few cities.

CONCLUSION

The number of acute myocardial infarction cases was decreased during COVID-19 lockdown in our study population, as noted elsewhere. There are many reasons for the change in occurence including patient's deferral to seek medical attention because of fear of the infection of COVID-19. Hence, mandatory public health education and reassurance are required to prevent mortality from life-threatening illness. In addition, promotion of tele or virtual health consultation is required during such crisis. Also, reduction in the environmental risk factors may be a reason for the reduced occurence of MI and hence, policies on the environmental health are regulated and monitored periodically.

Abbreviations and Acronyms: COVID-19 = coronavirus disease 2019; **MI =** myocardial infarction; **NSTEMI =** non—ST-segment elevation myocardial infarction; **STEMI =** ST-segment elevation myocardial infarction

Affiliations (Continued from the first page of this article.): Research Institute, Madurai, Tamil Nadu, India (affiliated to The Tamil Nadu Dr. M.G.R. Medical University, Chennai) (R.V.); Apollo Specialty Hospitals, Tiruchirappalli, Tamil Nadu, India (S.A.); and Sri Gokulam Specialty Hospitals, Salem, Tamil Nadu, India (V.P.C.).

Correspondence: Address to Ramachandran Meenakshisundaram, MBBS, MRCP, PhD, PGCert in HBE, FHEA, 47 Hurrell Dr, Harrow HA2 6DY, UK (rmsundarchandran@gmail.com; Twitter: @rmsundarchandra).

ORCID
Ramachandran Meenakshisundaram: https://orcid.org/0000-0002-1281-3346; Melvin Joy: https://orcid.org/ 0000-0001-9323-994X; Ramalingam Vadivelu: https:// orcid.org/0000-0002-7195-3648

REFERENCES

1. De Filippo O, D'Ascenzo F, Angelini F, et al. Reduced rate of hospital admissions for ACS during Covid-19 outbreak in Northern Italy. *N Engl J Med.* 2020;383(1):88-89.
2. Garcia S, Albaghdadi MS, Meraj PM, et al. Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States during COVID-19 pandemic. *J Am Coll Cardiol.* 2020;75(22):2871-2872.
3. Rodríguez-Leor O, Cid-Álvarez B, Ojeda S, et al. Impacto de la pandemia de COVID-19 sobre la actividad asistencial en cardiología intervencionista en España. *REC Interv Cardiol.* 2020;2:82-89.
4. Rangé G, Hakim R, Motreff P. Where have the ST-segment elevation myocardial infarctions gone during COVID-19 lockdown? *Eur Hear J Qual Care Clin Outcomes.* 2020;6(3):223-224.
5. The Lancet. India under COVID-19 lockdown. *Lancet.* 2020; 395(10233):1315.
6. Roth GA, Johnson C, Abajobir A, et al. Global, regional, and national burden of cardiovascular diseases for 10 causes, 1990 to 2015. *J Am Coll Cardiol.* 2017;70(1):1-25.
7. Guo S, Niu Y, Cheng Y, et al. Association between ambient temperature and daily emergency hospitalizations for acute coronary syndrome in Yancheng, China. *Environ Sci Pollut Res Int.* 2020;27(4):3885-3891.
8. Sharif Nia H, Chan YH, Froelicher ES, et al. Weather fluctuations: predictive factors in the prevalence of acute coronary syndrome. *Heal Promot Perspect.* 2019;9(2):123-130.
9. Kuźma Ł, Pogorzelski S, Struniawski K, Dobrzycki S, Bachórzewska-Gajewska H. Evaluation of the influence of air pollution on the number of hospital admissions for acute coronary syndrome in elderly patients. *Pol Arch Intern Med.* 2019;130(1):38-46.
10. Guarnieri M, Balmes JR. Outdoor air pollution and asthma. *Lancet.* 2014;383(9928):1581-1592.
11. Loughnan ME, Nicholls N, Tapper NJ. The effects of summer temperature, age and socioeconomic circumstance on acute myocardial infarction admissions in Melbourne, Australia. *Int J Health Geogr.* 2010;9:41.
12. Wong LE, Hawkins JE, Langness S, Murrell KL, Iris P, Sammann A. Where are all the patients? Addressing Covid-19 fear to encourage sick patients to seek emergency care [published online ahead of print May 14, 2020]. *NEJM Catal.* https://doi.org/10.1056/CAT.20.0193.
13. Münzel T, Schmidt FP, Steven S, Herzog J, Daiber A, Sørensen M. Environmental noise and the cardiovascular system. *J Am Coll Cardiol.* 2018;71(6):688-697.
14. NASA. European Space Agency data show drop in air pollution in india during COVID-19 lockdown. Firstpost website. https://www.firstpost.com/tech/science/nasa-european-space-agency-data-show-drop-in-air-pollution-in-india-during-covid-19-lockdown-8304391.html. Accessed May 8, 2020.
15. Muhammad S, Long X, Salman M. COVID-19 pandemic and environmental pollution: a blessing in disguise? *Sci Total Environ.* 2020;728:138820.
16. Baldi E, Sechi GM, Mare C, et al. Out-of-hospital cardiac arrest during the Covid-19 outbreak in Italy. *N Engl J Med.* 2020; 383(5):496-498.
17. Strøm A, Jensen RA. Mortality from circulatory diseases in Norway. *Lancet.* 1951;257(6653):528.
18. Zagury-Orly I, Schwartzstein RM. Covid-19—a reminder to reason. *N Engl J Med.* 2020;383(3):e12.
19. Finset A, Bosworth H, Butow P, et al. Effective health communication—a key factor in fighting the COVID-19 pandemic. *Patient Educ Couns.* 2020;103(5):873-876.