

Supplementary Online Content

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eTable 1. Demographics and clinical characteristics of patients in validation cohorts

eTable 2. External validation of the COVID-GRAM

eFigure 1. Feature selection using the least absolute shrinkage and selection operator (LASSO) binary logistic regression model. (A) LASSO coefficient profiles of the 72 baseline features. (B) Tuning parameter (λ) selection in the LASSO model used 10-fold cross-validation via minimum criteria

eFigure 2. The area under the receiver-operator characteristic (ROC) curve (AUC) of predicting critical illness among patients with COVID-19

eFigure 3. External validation of COVID-GRAM in an independent cohort

eFigure 4. External validation of COVID-GRAM in four independent cohorts

eAppendix. Acknowledgements

This supplementary material has been provided by the authors to give readers additional information about their work.

eTable 1. Demographics and clinical characteristics of patients in validation cohorts

	Foshan (n=73)	Hubei (n=381)	Daye (n=191)	Wuhan (n=79)
Age (year)	43.8±15.5	48.6±13.8	45.5±15.5	56±17.3
NLR	4.1±6.1	4.2±4.7	6.2±6.5	14.1±18.8
Lactate dehydrogenase (U/L)	466.6±190.9	250.2±78.9	241.9±116.2	414.4±239.4
Direct bilirubin (umol/L)	2.6±3.6	4.2±4.4	23.1±3.3	10.2±9.5
Abnormal chest radiograph	61 (12.1)	29 (7.6)	164 (85.9)	3 (3.6)
Hemoptysis	0	2 (0.5)	4 (2.1)	2 (2.4)
Shortness of breath	18 (3.6)	3 (0.8)	9 (4.7)	48 (57.1)
Unconsciousness	0	2 (0.5)	0	3 (3.6)
Comorbidities				
0	56 (11.1)	307 (80.6)	144 (75.4)	43 (51.2)
1	11 (2.2)	48 (12.6)	31 (16.2)	13 (15.5)
2	4 (0.8)	22 (5.8)	12 (6.3)	18 (21.4)
3	2 (0.4)	2 (0.5)	4 (2.1)	2 (2.4)
4	0	2 (0.5)	0	1 (1.2)
Malignancy	0	2 (0.5)	7 (3.7)	6 (7.1)
Critical illness	2 (0.4)	9 (2.4)	16 (8.4)	60 (71.4)

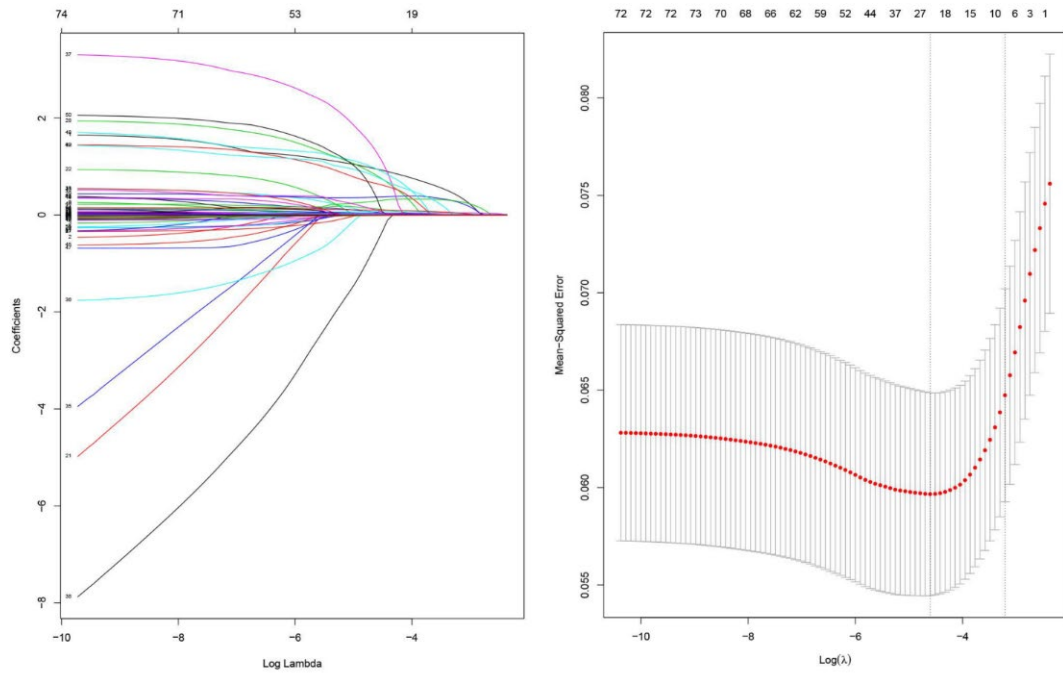
NLR=neutrophil-lymphocyte ratio

eTable 2 External validation of the COVID-GRAM

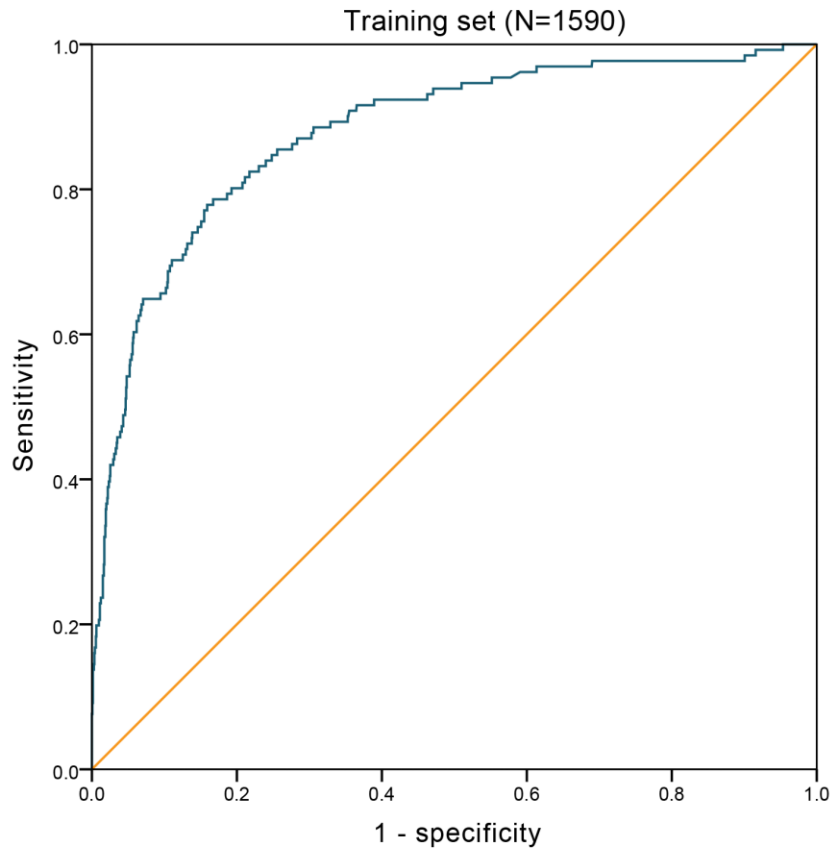
Source	Time interval	N	AUC
Hubei multiple centers*	until Jan 31	381	0.886 (0.733-1)
Jinyintan Hopital, Hankou Hospital, Wuhan Union hospital (Wuhan, Hubei)	until Feb 28	79	0.883 (0.790-0.976)
Foshan Hospital (Guangdong)	until Feb 28	73	0.979 (0.938-1)
Daye Hospital (Hubei, non- Wuhan)	until Feb 28	191	0.887 (0.822-0.952)

***These cases were not overlapped with any other cohort.**

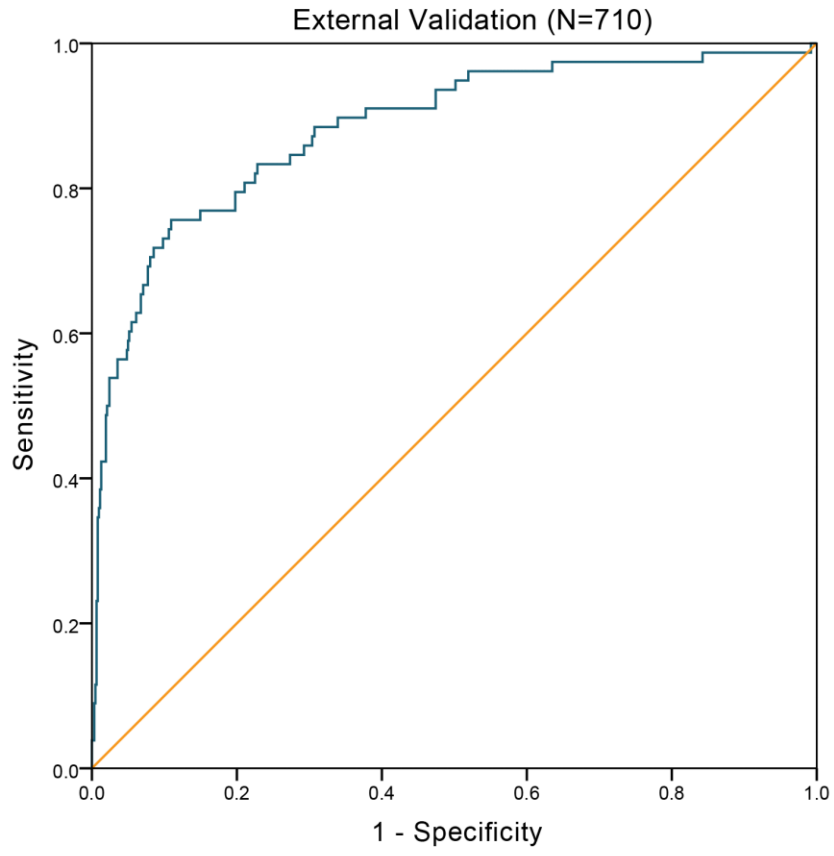
eFigure 1



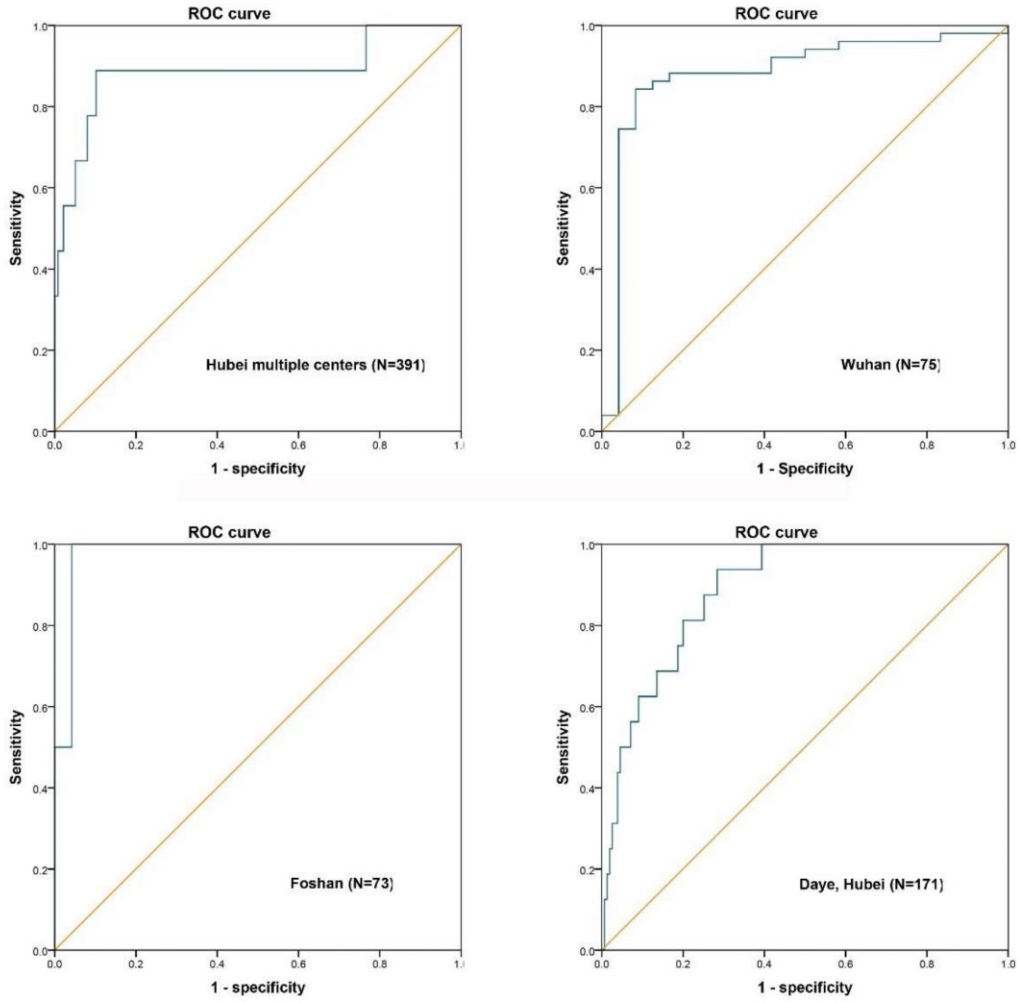
eFigure 2



eFigure 3



eFigure 4



Acknowledgements

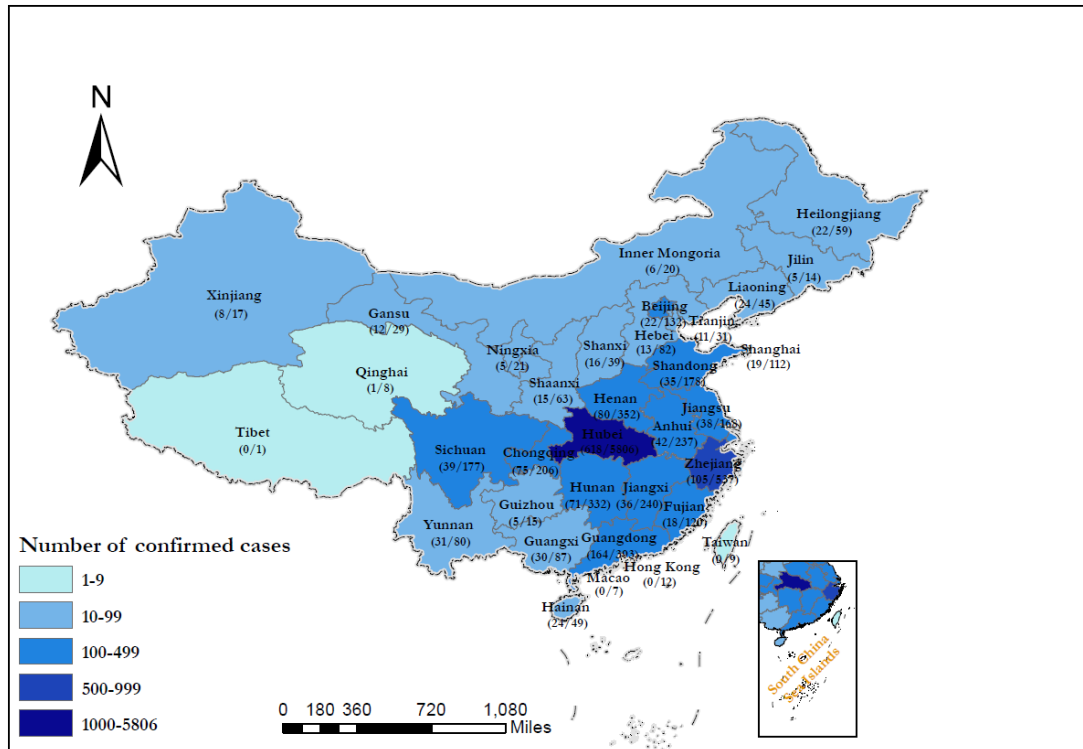
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List of hospitals reporting the included cases



Wuhan Jinyintan hospital, Union Hospital Affiliated to Tongji Medical College of Huazhong University of science and technology, Wuhan Central Hospital, Wuhan first hospital, Chengdu Public Health Clinical Medical Center, Huangshi Central Hospital, Shenzhen Third People's Hospital, Wuhan Pulmonary Hospital, Tianyou Hospital Affiliated to Wuhan University of science and technology, Changsha First Hospital, The third people's Hospital of Hainan Province, Huanggang Central Hospital, Wenling first people's Hospital, Yichang Third People's Hospital, Taihe Hospital Affiliated to Hubei Medical College, Xiantao first people's Hospital, Wuhan Huangpi District People's Hospital, Jingzhou Chest Hospital, Jingzhou first people's Hospital, Shanghai Public Health Clinical Center, Beijing You'an Hospital Affiliated to Capital Medical University, Zhengzhou Sixth People's Hospital, Chongqing Three Gorges Central Hospital, The ninth Affiliated Hospital of Guangxi Medical University, Hangzhou Xixi hospital, Nanjing Second Hospital, Suzhou Fifth People's Hospital, The first hospital of Zhejiang Province, The Fifth Affiliated Hospital of Zhongshan University, Huangshi traditional Chinese medicine hospital,

Yangjiang people's Hospital, Zhongxian hospital, the First Affiliated Hospital of Chongqing Medical University, Anqing Municipal Hospital, Changzhou Third People's Hospital, Guangzhou first people's Hospital, Harbin infectious diseases hospital, Tianmen first people's Hospital, Wuxi People's Hospital, Wuhan fifth hospital, Xishuangbanna Dai Autonomous Prefecture People's Hospital, Chongqing Iron and Steel General Hospital, Daye people's Hospital, Nanxishan Hospital of Guangxi Zhuang Autonomous Region, Jiaxing First Hospital, Jiangling people's Hospital, Jinzhong infectious disease hospital, Lanzhou Pulmonary Hospital, Liuzhou people's Hospital, Ma'anshan He county people's Hospital, The First Affiliated Hospital of Nanchang University, Ningbo Yinzhou people's hospital medical community, Shaoxing people's Hospital, Shijiazhuang fifth hospital, Taizhou Enze Medical Center, Xinyang Central Hospital, Yueyang No.1 People's Hospital, Zhanjiang Central People's Hospital, The First Affiliated Hospital of Zhengzhou University, Shenzhen Hospital of Chinese Academy of Sciences, Chongqing Kaizhou District People's Hospital, Chongqing Changshou District People's Hospital, Chongqing Yunyang County People's Hospital, Ankang Central Hospital, Chenzhou Second People's Hospital, Datong Fourth People's Hospital, Dengzhou people's Hospital, Fengjie people's Hospital, Foshan first people's Hospital, Fuyang Second People's Hospital, Gongyi people's Hospital, Guangshan people's Hospital, Guoyao Dongfeng General Hospital, Hainan people's Hospital, The Second Affiliated Hospital of Hainan Medical College, The first people's Hospital of Xiaoshan District, Hangzhou, Huaihua first people's Hospital, Jiashan first people's Hospital, Lu'an people's Hospital, Affiliated Hospital of Qingdao University, Qingyuan people's Hospital, Quanzhou County People's Hospital, Rizhao people's Hospital, Shaodong people's Hospital, Shiyuan Xiyuan Hospital, Tongling people's Hospital, Wenzhou People's Hospital, Wenzhou Central Hospital, The Second Affiliated Hospital of Wenzhou Medical University, Wuxi Fifth People's Hospital, Wuhan Youfu hospital, Xi'an eighth hospital, Xinxiang infectious disease hospital, Yangxin County People's Hospital, Yuebei Second People's Hospital, Yunnan infectious diseases hospital, Zhaoqing first people's Hospital, Zhaozhou County People's Hospital, Shao Yifu Hospital Affiliated to Zhejiang University School of Medicine, Zhijiang people's Hospital, People's Hospital of Dianjiang County, Chongqing, Chongqing Jiulongpo first people's

Hospital, Chongqing Shizhu Tujia Autonomous County People's Hospital, The first people's Hospital of Wanzhou District, Chongqing, Yongchuan Hospital Affiliated to Chongqing Medical University, Anguo hospital, The Third Hospital of Peking University, peking university shenzhen hospital , BOLUO people's Hospital, Changde Lixian people's Hospital, Changde Second People's Hospital, Chenzhou Central Hospital, Chengjiang people's Hospital, Dalian Central Hospital, Danzhou people's Hospital, Dengzhou Central Hospital, Feidong County People's Hospital, Fuzhou Nanfeng County Hospital, Ganzhou Fifth People's Hospital, Gao'an people's Hospital, Public Security County People's Hospital, Affiliated Hospital of Guangdong Medical University, The Sixth Affiliated Hospital of Guangzhou Medical University, Affiliated Hospital of Guizhou Medical University, Hangzhou first people's Hospital, Hangzhou Lin'an District People's Hospital, Nanpi County Hospital of traditional Chinese medicine of Hebei Province, Henan people's Hospital, Hefeng County Central Hospital, Hohhot First Hospital, Huludao Central Hospital, The First Affiliated Hospital of Hunan Medical College, Shenzhen Union Hospital of Huazhong University of science and technology, Huaibei people's Hospital, Huangshi Second Hospital, Huangchuan people's Hospital, Huizhou Zhongda Huiya hospital, Huizhou Central People's Hospital, Jining first people's Hospital, Jianshi County People's Hospital, Fengcheng people's Hospital of Jiangxi Province, Jiangyou infectious diseases hospital, Jieyang people's Hospital, Jinhua Central Hospital, Jinzhong Pingyao people's Hospital, Jingjiang people's Hospital, The Second Affiliated Hospital of Kunming Medical University, Laifeng County Central Hospital, Yueqing people's Hospital, Lijiang people's Hospital, Lixin people's Hospital, The Fourth People's Hospital of Lianyungang, Linqu County People's Hospital, Linyi people's Hospital, Longxi first people's Hospital, Min Da Hospital, Minqing County General Hospital, Nantong Third People's Hospital, Nanyang Central Hospital, The First Affiliated Hospital of Nanyang Medical College, Nanyang Oilfield General Hospital, Ningbo First Hospital, The Fourth People's Hospital of Ningxia, Pingxiang Second People's Hospital, Quzhou Kecheng District People's Hospital, Qujing maternal and child hospital, Ruian people's Hospital, The First Affiliated Hospital of Xiamen University, Shangcheng County People's Hospital, Shanghai Baoshan Dachang hospital, Shanghai Pudong New Area Gongli Hospital , People's

Hospital of Yushan County, Jiangxi Province, Shangrao City, Xuanwu Hospital of Capital Medical University, Sichuan Mianyang 404 hospital, Sixian Hospital of traditional Chinese Medicine, Suihua First Hospital, Suiping County People's Hospital, Tianjin Fourth Central Hospital, Tianjin Haihe hospital, Tiantai County People's Hospital, Tongchuan Mining Bureau Central Hospital, Tongren people's Hospital, Weihai Central Hospital, The First Affiliated Hospital of Wenzhou Medical University, Wuzhou Third People's Hospital, Armed police Hubei provincial general team hospital, Xixian people's Hospital, Longshan County People's Hospital in Western Hunan, Xiangcheng first people's Hospital, The Sixth People's Hospital of Xinjiang Uygur Autonomous Region, The First Affiliated Hospital of Xinjiang Medical University, Xinmi Hospital of traditional Chinese Medicine, Xinxiang County People's Hospital, Xinye people's Hospital, Xinyang first people's Hospital, Xinyang Hospital of traditional Chinese Medicine, Xuanen County People's Hospital, Xinhua Hospital, Yili Prefecture, Yongzhou Central Hospital, Yuyao people's Hospital, Changchun infectious disease diagnosis and treatment center, Changsha eighth hospital, Changsha first people's Hospital, 921st Hospital of the joint service support force of the Chinese people's Liberation Army, Central theater General Hospital of the Chinese people's Liberation Army, The First Affiliated Hospital of China Medical University, The Third Affiliated Hospital of Zhongshan University, Zhongshan Second People's Hospital, Chongqing Chengkou people's Hospital, Chongqing Hechuan District People's Hospital, Chongqing Red Cross Hospital, Zhoushan women's and children's Hospital, Zhoukou infectious diseases hospital, Zhuzhou first people's Hospital, Zhumadian Central Hospital, Anlong people's Hospital, Anxi County Hospital, Anyang Fifth People's Hospital, Anyang People's Hospital, Anyuan people's Hospital, Badong County Ethnic hospital, Wuyuan County People's Hospital of Bayannur City, Baise people's Hospital, The First Affiliated Hospital of Bengbu Medical College, Baoding first Central Hospital, Changping District Hospital of Beijing Municipality, Changping District Hospital of traditional Chinese and Western medicine of Beijing, Beijing Chuiyangliu Hospital, Beijing Center for Disease Control and Prevention, Mentougou District Hospital of Beijing Municipality, Shunyi District Hospital of Beijing Municipality, Beijing Xicheng District Guangwai hospital, Oriental Hospital of Beijing University of traditional Chinese

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and Prevention Center, Huizhou Third People's Hospital, Huadu District People's Hospital, The Third Affiliated Hospital of Guangzhou Medical University, Guangzhou Chest Hospital, Guangzhou Haizhu Center for Disease Control and Prevention, Guangning people's Hospital, Zhuhai Hospital of Guangdong Hospital of traditional Chinese Medicine, Guangdong hydropower hospital Co. Ltd, Guangdong Provincial People's Hospital, The second people's Hospital of Guangdong Province, Panyu District Central Hospital, Dongguan Dalang hospital, Chaozhou Central Hospital