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Review article: gastrointestinal features in COVID-19 and the possibility of faecal transmission

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Summary

Background: There is little published evidence on the gastrointestinal features of COVID-19.

Aims: To report on the gastrointestinal manifestations and pathological findings of patients with COVID-19, and to discuss the possibility of faecal transmission.

Methods: We have reviewed gastrointestinal features of, and faecal test results in, COVID-19 from case reports and retrospective clinical studies relating to the digestive system published since the outbreak.

Results: With an incidence of 3% (1/41)-79% (159/201), gastrointestinal symptoms of COVID-19 included anorexia 39.9% (55/138)-50.2% (101/201), diarrhoea 2% (2/99)-49.5% (146/295), vomiting 3.6% (5/138)-66.7% (4/6), nausea 1% (1/99)-29.4% (59/201), abdominal pain 2.2% (3/138)-6.0% (12/201) and gastrointestinal bleeding 4% (2/52)-13.7% (10/73). Diarrhoea was the most common gastrointestinal symptom in children and adults, with a mean duration of 4.1 ± 2.5 days, and was observed before and after diagnosis. Vomiting was more prominent in children. About 3.6% (5/138)-15.9% (32/201) of adult and 6.5% (2/31)-66.7% (4/6) of children patients presented vomiting. Adult and children patients can present with digestive symptoms in the absence of respiratory symptoms. The incidence of digestive manifestations was higher in the later than in the early stage of the epidemic, but no differences in digestive symptoms among different regions were found. Among the group of patients with a higher proportion of severe cases, the proportion of gastrointestinal symptoms in severe patients was higher than that in nonsevere patients (anorexia 66.7% vs 30.4%; abdominal pain 8.3% vs 0%); while in the group of patients with a lower severe rate, the proportion with gastrointestinal symptoms was similar in severe and nonsevere cases (nausea and vomiting 6.9% vs 4.6%; diarrhoea 5.8% vs 3.5%). Angiotensin converting enzyme 2 and virus nucleocapsid protein were detected in gastrointestinal epithelial cells, and infectious virus particles were isolated from faeces. Faecal PCR testing was as accurate as respiratory specimen PCR detection. In 36% (5/14)-53% (39/73) faecal PCR became positive, 2-5 days later than sputum PCR positive. Faecal excretion persisted after sputum excretion in 23% (17/73)-82% (54/66) patients for 1-11 days.

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Conclusions: Gastrointestinal symptoms are common in patients with COVID-19, and had an increased prevalence in the later stage of the recent epidemic in China. SARS-CoV-2 enters gastrointestinal epithelial cells, and the faeces of COVID-19 patients are potentially infectious.

1 | INTRODUCTION

Up to the submission date, a novel coronavirus (severe acute respiratory syndrome coronavirus 2 [SARS-CoV-2], previously called 2019-nCoV) initially reported in Wuhan, China has been diagnosed in more than 200 000 people from 166 countries worldwide according to the World Health Organization (WHO). SARS-CoV-2 is currently the world's most pressing public health threat and has a significant impact on the lives of people around the world.

SARS-CoV-2 is an enveloped, positively charged, single-stranded RNA virus belonging to the beta coronavirus genus. SARS-CoV-2 enters cells via the angiotensin converting enzyme 2 (ACE2) receptor and is highly homologous to SARS-CoV.[1] Zhang et al[2] reported that ACE2 was highly expressed in oesophageal epithelial cells and the absorptive enterocytes from ileum and colon, suggesting possible faecal transmission. Gastrointestinal symptoms such as vomiting and diarrhoea have been reported in SARS patients[3] and in COVID-19 patients. Currently, there are few data on the gastrointestinal manifestations of COVID-19. The clinical case analyses on digestive manifestations and pathological findings of patients with COVID-19 published in China were reviewed in this paper with a view to providing reference for prevention and control, as well as diagnosis and treatment of the disease.

2 | METHODS

2.1 | Inclusion and exclusion criteria

We included data on COVID-19 patients who have confirmed in case reports and retrospective clinical studies relating to the digestive system that were published in English or Chinese from the end of December 2019 to the end of February 2020. Studies that did not mention digestive symptoms were excluded. Most of the patients were from China, including Wuhan city and areas outside Wuhan.

2.2 | Literature search

The review was based on PubMed and China National Knowledge Internet information sources including reports, publications and data collected by the WHO and National Health Commission of the People's Republic of China, and 'grey' literature information sources including Baidu Scholar and Google Scholar. We performed extensive hand searching of reference lists of papers and reports. The search terms used were '2019-nCoV', 'SARS-CoV-2' or 'COVID-19' combined with 'gastrointestinal', 'clinical feature', 'digestive', or 'pathological' and 'faeces' or 'stool'.

2.3 | Data extraction

We reviewed eligible studies and extracted data on province or city, study time period, patient age group range, study size, severity of illness, symptom categories and the incidence of symptoms. We also extracted sensitivity of faecal PCR test and time window between faecal and respiratory PCR test, if mentioned. When extracting information from the studies, pairs of researchers conferred to compare findings and reach consensus. Where consensus was not reached, an independent researcher was consulted.

3 | RESULTS

3.1 | Gastrointestinal symptoms in COVID-19

We identified data from 2023 patients where presence or absence of gastrointestinal symptoms had been reported. Among COVID-19 patients, gastrointestinal symptoms reported during disease progression varied widely. The latest data[4] from Wuhan showed that up to 79% of the patients presented such gastrointestinal symptoms as diarrhoea, decreased appetite, nausea, vomiting, abdominal pain and gastrointestinal bleeding during the onset and subsequent hospitalisation. Although the recent symptom proportion in Wuhan was high, the first clinical article about clinical characteristics of COVID-19 mentioned that only 3% patients had diarrhoea.[5] Table 1 shows the current literature related to gastrointestinal features. Anorexia was the most frequent digestive symptom in adults (39.9%-50.2%), while diarrhoea was the most common symptom both in adults and children (2%-49.5%), and vomiting was more common in children. About 3.6%-15.9% of adult patients presented vomiting and 6.5%-66.7% in children. Nausea accounted for 1%-29.4%, and gastrointestinal bleeding was 4%-13.7%; abdominal pain (2.2%-6.0%) was more frequent in severely ill patients.

There are a few reports indicating that small number of patients only presented with diarrhoea and vomiting without fever and cough. Ping et al[10] reported only nine adult patients with digestive symptoms and no other symptoms at onset. During hospitalisation, four of nine patients never had respiratory symptoms or fever. The other five patients developed a fever 2-4 days after onset. Six of nine patients went to the gastroenterology clinic, and the other three patients went to other department clinics. No one visited the

TABLE 1 Gastrointestinal manifestations in patients with SARS-CoV-2 infection

	Date	Region	Total patients	Age of affected patients average ± SD/ median (range)	Duration of diarrhoea	Disease severity of patients with GI symptoms		Gastrointestinal symptoms		Patients with GI symptoms without respiratory symptoms	Notes
Huang et al[5]	16 December-2 January	Wuhan	41	49 (IQR 41-58) y	NA	Non-ICU		Diarrhoea	1 (3%)	NA	Suggest to test faecal and urine samples to exclude a potential alternative route of transmission
Yang et al[6]	Late December-26 January	Wuhan	52	59.7 ± 13.3 y	NA	All critically ill patients		Gastrointestinal haemorrhage Vomiting	2 (4%) 2 (4%)	NA	—
Liu et al[7]	1 January-15 January	Wuhan	6 children	3 (1-7) y	NA	1 critical case 5 mild-moderate cases		Vomiting	4 (66.7%)	NA	—
Chen et al[8]	1 January-20 January	Wuhan	99	55.5 ± 13.1 y (21-82)	NA	NA		Diarrhoea Nausea and vomiting	2(2%) 1(1%)	NA	—
Wang et al[9]	1 January-28 January	Wuhan	138	56 (22-92) y	NA	36 ICU Anorexia 24(66.7%) Diarrhoea 6 (16.7%) Nausea 4 (11.1%) Vomiting 3 (8.3%) Abdominal pain 3 (8.3%)	102 non-ICU Anorexia 31(30.4%) Diarrhoea 8 (7.8%) Nausea 10 (9.8%) Vomiting 2 (2.0%) Abdominal pain 0 (0%)	Anorexia Diarrhoea Nausea Vomiting Abdominal pain	55 (39.9%) 14 (10.1%) 14 (10.1%) 5 (3.6%) 3 (2.2%)	14 (10.1%) patients initially presented with diarrhoea and nausea before typical symptoms of fever and dyspnoea One patient presented with abdominal symptoms and was admitted to the surgical department, and infected more than 10 health care workers in this department and 4 hospitalised patients in the same ward	ICU patients were more likely to present anorexia and abdominal pain
Ping et al[10]	17 January-24 January	Wuhan	9	35.8 (28-45) y	NA	No critical cases		Anorexia Nausea Vomiting Diarrhoea	6 1 1 1	All nine patients showed only digestive symptoms with no fever onset, and four patients never had respiratory symptoms or fever	The time between initial nonspecific and specific symptoms was 2-5 d Digestive symptoms occurred 1-3 days (median 2.1 d) before the patients' visit
Wei et al[11]	23 January-8 February	Wuhan	20 children	2 years and 1.5 mo (1 d-14 y 7 mo)	NA	All the patients had good prognosis		Diarrhoea Vomiting	3 (15%) 2 (10%)	NA	—

(Continues)

TABLE 1 (Continued)

	Date	Region	Total patients	Age of affected patients average ± SD/ median (range)	Duration of diarrhoea	Disease severity of patients with GI symptoms		Gastrointestinal symptoms		Patients with GI symptoms without respiratory symptoms	Notes
Fang et al[4]	27 January-14 February	Wuhan	305	57 (18-95) y	4.1 ± 2.5 d (1-14)	46 critical cases	259 noncritical cases	Diarrhoea	146/295 (49.5%)	NA	Diarrhoea appeared 1-8 d after onset, with a median time of 3.3 d The frequency of diarrhoea was up to nine times per day, median of (3.3 ± 1.6) times per day, 34.3% were watery stools 55.2% (58/105) of patients had diarrhoea after drugs estimating 22.2% of the patients had nondrug-related diarrhoea
						Digestive symptom 17/20 (85.0%)	Digestive symptom 142/181 (78.5%)	Loss of appetite	101/201 (50.2%)		
								Nausea	59/201 (29.4%)		
						Diarrhoea 17/38 (44.7%)	Diarrhoea 129/257 (50.2%)	Vomiting	32/201 (15.9%)		
								Abdominal pain	12/201 (6.0%)		
Chang et al[12]	16 January-29 January	Beijing	13	34 (IQR 34 -48) y	NA	NA		Diarrhoea	1 (7.7%)	NA	—
Guan et al[13]	11 December-29 January	30 provinces	1099	47 (IQR 35 -58) y	NA	173 Severe	926 Nonsevere	Nausea or vomiting	55 (5.0%)	NA	—
						Nausea and vomiting 12 (6.9%)	Nausea and vomiting 43 (4.6%)				
						Diarrhoea 10 (5.8%)	Diarrhoea 32 (3.5%)	Diarrhoea	42(3.8%)		
Xu et al[14]	10 January-26 January	Zhejiang province	62	41(IQR 32-52) y	>10 d	1 critical case		Diarrhoea	3 (5%)	NA	Three patients showed diarrhoea at onset
Song et al[15]	20 January-27 January	Shanghai	51	49 ± 16 y (16-76)	NA	NA		Diarrhoea	5 (10%)	NA	—
								Nausea and vomiting	3 (6%)		
Hu et al[16]	28 January-9 February	Nanjing	24 asymptomatic onset cases	32.5 (5-59) y 5 cases <15 y	NA	All cases were mild-moderate		Diarrhoea	2 (8.3%)	NA	Diarrhoea was considered as a reaction of drugs

(Continues)

TABLE 1 (Continued)

	Date	Region	Total patients	Age of affected patients average ± SD/ median (range)	Duration of diarrhoea	Disease severity of patients with GI symptoms	Gastrointestinal symptoms		Patients with GI symptoms without respiratory symptoms	Notes
Wang et al[17]	25 January-21 February	Six provinces in North	31 children	7 y 1 mo, (6 mo-17 y)	NA	All cases were asymptomatic or mild-moderate	Diarrhoea Vomiting	3 (9.6%) 2 (6.5%)	Three cases had diarrhoea and one case had vomiting as the first symptom without fever or cough	Three cases with diarrhoea were yellow thin faeces, two to six times per day, and no symptoms of dehydration and electrolyte disturbance
Xiao et al[18]	1 February-14 February	Guangzhou	73	10 mo-78 y	NA	NA	Diarrhoea Gastrointestinal bleeding	26 (35.6%) 10 (13.7%)	NA	17/26 (65.4%) patients with diarrhoea were stool PCR positive 4/10 (40%) patients with gastrointestinal bleeding were stool PCR positive

emergency department, fever clinic or respiratory department at first. All of the nine patients had a history of exposure to confirmed or suspected SARS-CoV-2-infected patients and were confirmed by the throat swab test after screening. One adult patient mentioned in another article presented with abdominal symptoms and was admitted to the surgical department, and was presumed to infect more than 10 health care workers in this department and four hospitalised patients in the same ward. One of the patients in the same ward was diagnosed as having SARS-CoV-2 infection after the appearance of fever, and found the initially hospitalised patient was infected with SARS-CoV-2. All of the four patients in the same ward presented with abdominal symptoms and fever.[9] An article with 31 children mentioned that three children had diarrhoea as the first symptom and one had vomiting without fever and cough.[17] No mention was made of respiratory symptoms during subsequent hospitalisations.

Diarrhoea might be the first symptom before diagnosis, while some appeared after confirmation of SARS-CoV-2 infection. Fang et al[4] found that diarrhoea occurred in 49.5% (146/295) patients, 55.2% of which occurred after admission and anti-virus therapy, and estimated 22.2% of patients presented diarrhoea before diagnosis. Diarrhoea occurred from 1 to 8 days after the onset, with a median time of 3.3 days. The mean duration of symptoms was 4.1 ± 2.5 days, and varied between 1 and 14 days. The frequency of diarrhoea was 3.3 ± 1.6 per day, and up to nine times per day in some patients; 34.3% had yellow-watery stools.[4] Wang et al[17] found similar results; three of 31 children with diarrhoea had thin yellow stools, two to six times per day, and all had diarrhoea as the first symptom. Laboratory faecal test results showed that 6.9% of the patients had faecal abnormalities, with 5.2% positive for leukocytes and 1.7% for occult blood but no red blood cells, which is consistent with the characteristics of viral diarrhoea.[4] The relevant treatment strategy for diarrhoea is usually symptomatic, and drugs used in the clinic mainly included dioctahedral montmorillonite powder and loperamide as appropriate to relieve the symptoms, probiotics mitigating intestinal microflora dysbiosis and antispasmodics if accompanied by abdominal pain. Properly rehydration therapy as necessary to maintain electrolyte balance.[19]

Contradictory results about digestive symptoms in severe and nonsevere patients have been reported. Fang et al[4] found that 46 of the 305 patients were critically ill, accounting for 15.1%. About 85% (17/20) critical cases had digestive symptoms and 44.7% (17/38) had diarrhoea. The results were not statistically different from those of noncritical cases, where digestive symptoms in nonsevere patients accounted for 78.5% (142/181), of which 50.2% (129/257) had diarrhoea. A similar result was observed in the study by Guan et al[13] They reported a severe and critical rate of about 15.7% (173/1099). There was no difference in these rates when compared with the proportion of gastrointestinal symptoms between severe and nonsevere cases (nausea and vomiting 6.9% vs 4.6%; diarrhoea 5.8% vs 3.5%). However, opposite results were found in another study. Wang et al[9] reported that the proportion of gastrointestinal symptoms, especially anorexia and abdominal pain, was higher in ICU patients than in non-ICU patients (anorexia 66.7% vs 30.4%; abdominal pain 8.3%

TABLE 2 Faecal RT-PCR test in patients with SARS-CoV-2 infection

	Total patients	Patients of positive faecal PCR test	Negative in respiratory PCR test but positive in faecal test	Time Differences between negative PCR test in stool and negative PCR test in respiratory specimens (d)
Ling et al[25]	66 convalescent patients	NA	54 (81.8%)	+2(+1 to +11)[a]
Zhang et al[26]	14	5 (35.7%)	NA	NA
Xiao et al[8]	73	39 (53.4%)	17 (23.3%)	NA
Yang et al[24]	7	NA	3 (42.9%)	+3, +6, +7

Abbreviation: PCR, polymerase chain reaction.

[a]Date of negative faecal PCR test minus date of negative respiratory specimens PCR test, median (range).

vs 0%), and there were statistical differences in the proportions. We noticed that the proportion of severe cases (36/138, 26.1%) was much higher than that in the two studies mentioned above, and were even higher than the severe and critical rate (18.5%) in the Chinese Centres for Disease Control (CDC) report of 72 314 cases.[20]

As mentioned in the CDC of China report, the epidemic curve of the onset of symptoms peaked between 23 January and 26 January 2020.[20] Noticeably, at the early stage of the epidemic before 26 January, the proportions of patients with diarrhoea reported in Wuhan and other regions outside Wuhan were similar at around 2%-10%. However, in the later stage of the epidemic, the proportion of patients with diarrhoea in Wuhan and areas outside Wuhan increased compared with the pre-epidemic stage. The increase was even more pronounced in Wuhan which had 49.5% of patients with diarrhoea,[4] compared with 35.6% in Guangdong.[18] Children had a similar rate of diarrhoea (9.6%-15%) as adults but had a higher rate of vomiting. One study reported up to 66.7% of children with vomiting, but only included six cases.[7] There were only two studies describing gastrointestinal bleeding. Yang et al[6] observed two cases (2/52, 4%) of gastrointestinal haemorrhage in critically ill patients. Xiao et al[18] reported 10 cases out of 73 (13.7%) but did not discuss severity.

3.2 | Gastrointestinal pathological findings

The first autopsy report was of an 85-year-old man with COVID-19. This showed segmental dilatation and stenosis of the small intestine.[21] Degeneration, necrosis and shedding of the gastrointestinal mucosa of varying degrees were found histologically in another patient who died of severe COVID-19.[19] Later, Xiao et al[18] reported no apparent mucosal epithelial damage in the oesophagus, stomach, duodenum and colorectum with H&E staining. Histology indicated occasional lymphocytic infiltration in the oesophageal squamous epithelium, and abundant infiltrating plasma cells and lymphocytes with interstitial oedema in stomach, duodenum and rectum lamina propria. ACE2 staining of pathological specimens showed that the positive areas were mainly distributed in the cytoplasm of gastric and intestinal epithelial cells and the cilia of glandular epithelial cells, but rarely observed in oesophageal squamous epithelial cells. Viral nucleocapsid protein was detected in the cytoplasm of gastric, duodenal and rectal glandular epithelial cells, but not in oesophageal epithelium, suggesting that the gastrointestinal symptoms of SARS-CoV-2 infection might be caused by the direct viral attack as well as tissue and organ damage due to the immune response.

3.3 | Faecal test for SARS-CoV-2

Substantial evidence from previous studies of SARS supported the gastrointestinal tract tropism of SARS-CoV, which was verified by viral detection in biopsy specimens and stool.[22] Similarly, SARS-CoV-2 was first reported in stool samples of the first case in the United States.[23] Yang et al[24] found that the stool specimens of three out of seven patients remained positive after a negative throat swab test. The results were subsequently confirmed by other studies (Table 2). The proportion of patients in whom stool samples tested positive was between 36% and 53% of all confirmed cases. Zhang et al[26] reported high accuracy of nucleic acid detection in stool samples. The comparison of stool test results to clinical manifestations as well as disease severity suggested that the positive rate of the faecal test was not differentially related to disease activity or digestive symptoms. The age of the patients with positive stool tests ranged between 10 months and 78 years, and the test lasted positive for approximately 1-16 days.[25,26] Available studies also demonstrated a time window in positive tests of specimens from different tissues.[24,25] The faecal nucleic acid was often positive 2-5 days after the respiratory specimens were found to be positive, and 23%-82% patients continued to have positive faecal tests while their respiratory specimens were negative.[24,25] The faecal test for patients treated with corticosteroids remained positive longer.[25] Recently, the isolation of infectious SARS-CoV-2 viruses from stool samples of COVID-19 patients[18] has directly proven that SARS-CoV-2 could be spread *via* faeces.

4 | DISCUSSION

We found that anorexia was the commonest gastrointestinal symptom; this might be explained by the inflammatory state, hypoxia, liver function injury, depression or adverse reactions to therapeutic

drugs. However, the assessment of loss of appetite was difficult because of its subjective nature; diarrhoea was a more objective finding. Different possible causes might account for diarrhoea. First, direct virus attack on the digestive tract could have resulted in diarrhoea; this is supported by the detection of viral nucleocapsid protein in epithelial cells. Second, the administration of anti-viral drugs or Chinese traditional medicines might also have contributed since they commonly induce nausea and diarrhoea. Third, dysbiosis of intestinal microbiota induced by antibiotics could have exacerbated digestive symptoms.

We noticed that the number of patients with diarrhoea increased in the later period of epidemic, which might indicate the reduced virulence of the virus in the process of transmission. We lacked sufficient knowledge of the virus at the beginning of the epidemic when the primary findings were dyspnoea and hypoxaemia. However, with an improved understanding of COVID-19, the digestive manifestations of the disease received much more attention; it is possible that drug-induced diarrhoea increased in the later stages.

This paper has a number of limitations. First, most of the articles involved were necessarily single-centre, retrospective studies, and no large-scale clinical statistics report was included. Second, as the epidemic developed, the continuously updated and improved diagnostic criteria for COVID-19 resulted in differences among the cases enrolled between the early and later stages of the epidemic. The initial diagnostic criteria included epidemiologic history, fever, changes in COVID-19 imaging and lymphopenia, and ineffective antibiotic treatment in combination of virus gene sequencing. However, the latest guidelines regarded patients having clinical manifestations but without epidemiologic history as suspected cases, and added RT-PCR detection and IgM/IgG antibody testing, so the diagnostic range for confirmed cases was expanded compared with the early stage of epidemic. Third, the lack of medical staff and resultant incomplete medical history and clinical data at the early stages of the epidemic might have caused some selection bias.

Latest study of 204 cases by Pan et al[27] showed that 99 patients (48.5%) had digestive symptoms, and 41 patients (20%) had a specific symptom (diarrhoea, vomiting and abdominal pain) excluding anorexia, and it is consistent with the results of our analysis. They noticed seven cases (3%) manifesting only digestive symptoms without respiratory symptoms. Patients with atypical primary symptoms or atypical first symptoms had also been reported in previous literature. It was an indicator that could help us to identify COVID-19 early and prompt the gastroenterologists to strengthen self-protection to reduce the potential risk of infection. Interestingly, they pointed out that patients with digestive symptoms were inclined to have a worse prognosis than those without digestive symptoms (34.3% discharged vs 60% discharged). We noticed that there were 74 (36%) critically ill patients in this paper and the severe and critical rate was much higher than the large-scale statistics rate in CDC report, which was 18.5%.[20] The results supported our finding that critical patients with high severe rate were more likely to manifest digestive symptoms. We may speculate that the high rate of severe cases indicated a high density and virulence of virus, which damaged the digestive system. The reason for the phenomenon is unclear, and should be verified by a larger clinical data in future research.

The proportion of children with vomiting was higher than that of adults. The vast majority of children with gastrointestinal symptoms were noncritically ill, only one of 57 children in the literature we reviewed was critically ill.[7,11,17] Gastrointestinal symptoms were also present in critically ill children,[28] but no specific data on gastrointestinal performance in severe children are currently available in the literature. It was reported that 10% (3/31) of the children showed only gastrointestinal symptoms instead of respiratory symptoms at onset,[17] which was higher than 3% (7/204) of adults.[27] It can be speculated that children might be more prone to gastrointestinal symptoms than respiratory symptoms compared with adults. One possibility is that the immature immune system in children might weaken the immune response in the respiratory system, leading to fewer respiratory symptoms. However, due to the limited number of children cases reported in the literature to date, drawing definite conclusion is difficult and needs to be confirmed by more clinical data.

It was difficult to assess whether the digestive symptoms were primary or secondary outcomes of SARS-CoV-2 infection in critically ill patients. Due to long-term hypoxemia, cell necrosis from tissue hypoxia may produce gastrointestinal mucosal cell injury, resulting in ulceration and bleeding. In view of the extremely high risk of virus transmission through aerosol during endoscopy, only one published study discussed endoscopic manifestations, and contained no details regarding mucosal damage. In addition, treatments including corticosteroids and NSAIDs, and the physiological stress in patients with severe illness could have affected the mucosa of the digestive tract, making it challenging to trace the cause.

The time window noticed between faecal and respiratory specimen PCR tests suggested that virus particles survived longer in the gastrointestinal tract than in the respiratory tract. When the viral load in the stool is high or in a virus-friendly environment, SARS-CoV-2 might spread easily *via* faeces. Ong et al[29] offered a typical example of faecal transmission. They collected samples from the bathroom of a patient with confirmed faecal positivity by RT-PCR and no diarrhoea. Samples from the surface of the toilet bowl, inside bowl of the sink and the door handle were positive results, while post-cleaning samples were negative. More details were given by von Doremalen et al[30] that viable virus existed for at least 3 hours in aerosols after their formation, and for up to 2 or 3 days on plastic and stainless steel surfaces. Based on the high viral infectivity of SARS-CoV-2, we believe that exposure to a faecal-contaminated environment, such as public toilets or areas with poor sanitation, may cause 'faecal-mucosal transmission' when individuals touch their mouth, nose or eyes with contaminated hands. Alternatively, the virus may infect patients' healthy family members through the faecal-aerosol-respiratory pathway by sharing toilets. More clinical and experimental data about virus viability in faeces and varying environmental conditions such as temperature and relative humidity are needed.

Early studies indicated that individuals infected with SARS-CoV-2 might shed and spread the virus while they were pre-symptomatic or asymptomatic.[31-33] Considering that viral shedding might last for more than a month,[34] we should pay attention to minimise the risk of faecal transmission. The latest treatment protocol in China stipulates that two RT-PCR tests of respiratory specimens carried out more than 24 h apart should be negative before a patient is discharged from the hospital, and that the patient should be isolated for 14 days after discharge.[19] In view of the possibility that stool samples of the discharged patient could still be positive, we suggest that the patient should implement a more thorough protocol for hand hygiene during isolation, thoroughly disinfect toilets and sinks, and try to avoid sharing toilets with family members. Meanwhile, we recommend a test for faecal nucleic acid before a patient is released from isolation. Medical staff who perform gastrointestinal endoscopy for isolated convalescent patients should consider all patients to be confirmed cases and take strict protective measures. Proper disinfection of toilets is crucial in endemic regions; otherwise, sanitation facilities can turn into 'virus traps'.

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AUTHORSHIP

Guarantor of the article: Long Rong and Yuan Tian.

Author contributions: All persons who meet authorship criteria are listed as authors. Long Rong designed the study. Yuan Tian and Long Rong reviewed the literature and provided the analysis. Yuan Tian drafted the manuscript. Long Rong and Weidong Nian revised the manuscript. Yan He participated in the literature search and discussion. All the authors read and approved the final manuscript.

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