

# BMJ Open Sociodemographic characteristics and health access associated with COVID-19 infection and death: a cross-sectional study in Malang District, Indonesia

Sujarwoto Sujarwoto ,<sup>1</sup> Asri Maharani<sup>2</sup>

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<sup>1</sup>Department of Public Administration, Brawijaya University, Malang, Jawa Timur, Indonesia

<sup>2</sup>Public Health and Epidemiology Department of Nursing, Manchester Metropolitan University, Lancashire, Manchester, UK

## Correspondence to

Dr Sujarwoto Sujarwoto;  
[sujarwoto@ub.ac.id](mailto:sujarwoto@ub.ac.id)

## ABSTRACT

**Objectives** This study aims to examine sociodemographic characteristics and health access associated with COVID-19 infection and death in Malang District, Indonesia.

**Design** A non-random cross-sectional study.

**Setting** Population in 390 villages in Malang District, East Java Province, Indonesia.

**Participants** We used Malang District government COVID-19 contact tracing data from 14 264 individuals, spanning from 1 March 2020 to 29 July 2020.

**Primary outcome measures** The outcome variables in this study are COVID-19 infections and COVID-19 deaths. The associations between sociodemographic characteristics and health access of COVID-19 infection and death were analysed using multilevel logistic regression.

**Results** Among the 14 264 samples, 551 individuals were confirmed as being infected with COVID-19; 62 individuals died of COVID-19. Women, individuals with direct contact with confirmed COVID-19 cases and individuals with hypertension constituted the groups most vulnerable to COVID-19 infection. Among respondents with confirmed COVID-19 cases, men, individuals aged 61 years and older, individuals with hypertension, and those diagnosed with pneumonia and respiratory failure were at higher risk of death. The number of community-based healthcare interventions was significantly associated with lower COVID-19 infection and COVID-19 mortality. Greater distance to a COVID-19 referral hospital increased risk of COVID-19 mortality.

**Conclusions** COVID-19 infection and death were related not only to sociodemographic characteristics of individuals but also to the presence of community-based healthcare interventions and access to hospital care. Strategies in public health, including improving healthcare access, are required to reduce COVID-19 infections among the most susceptible groups in Indonesia.

## INTRODUCTION

Understanding sociodemographic characteristics and health access associated with COVID-19 infections and deaths is vital for the development of effective mitigation strategies.<sup>1 2</sup> By identifying various sociodemographic characteristics such as age, gender, education, income, employment and

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ This study examines the association between sociodemographic characteristics, health access, and COVID-19 infection and death in a unique rural setting.
- ⇒ Multilevel or hierarchical regression analyses were applied to take full advantage of the village clustering information available from the data.
- ⇒ This is a rapid healthcare assessment based on 4 months of contact tracing data.
- ⇒ Some of the variables in this study were based on retrospective data, especially regarding respondents' histories of heart disease and diabetes.

living area as well as access to healthcare for infected individuals, we can determine conditions associated with COVID-19 infection and mortality. Hence, we may be able to identify certain vulnerable groups in the community whose members are at high risk of infection and death due to the virus. Policymakers need this information to formulate early detection and mitigation strategies to protect the community from COVID-19 infection risks and, most importantly, to minimise the number of deaths caused by the virus.

Earlier studies in Wuhan, China have shown that certain types of jobs are related to COVID-19 infection. It has been reported that occupational groups at risk include workers (and visitors) at seafood and wet animal wholesale markets.<sup>3</sup> Healthcare workers have been recognised as another group at high risk of infection.<sup>3</sup> In Beijing, it was found that individuals who had close contact with people with confirmed cases of COVID-19, as well as those who had been to Wuhan, were at risk of infection.<sup>4–6</sup> Studies have also reported that male sex, older age and comorbidities, especially cardiovascular metabolic diseases, confer a greater risk of death due to COVID-19 in Wuhan.<sup>5 6</sup> COVID-19 patients with diabetes had poorer



outcomes than sex-matched and age-matched patients without diabetes. Older age and comorbid hypertension contributed independently to in-hospital deaths among patients with diabetes.<sup>7,8</sup>

While earlier studies in Wuhan and Beijing have shown that close contact is related to infection, recent studies in the USA and UK have found additional sociodemographic characteristics, particularly ethnicity and socioeconomic background, to be linked with COVID-19 infection. Yancy reported that African-American or black people in New York City were contracting the virus at higher rates and were more likely to die than white Americans.<sup>2</sup> Also in New York City, Borjas found that people who lived in poor or immigrant neighbourhoods were more likely to become infected with COVID-19 than people who lived in wealthier, non-immigrant neighbourhoods.<sup>9</sup> In a recent study, Nasar and Hill reported disproportionate infection and mortality rates in black, Asian and minority ethnic communities in the UK.<sup>10</sup> Verhagen *et al* have explained that hospitals in some areas of the UK face a disproportionate risk of excessive pressure due to COVID-19 as a result of socioeconomic differences and the demographic composition of their populations, leaving poor families and poor regions behind.<sup>11</sup>

Health disparities and socioeconomic status have also been linked with COVID-19 deaths in the USA, UK and other wealthy countries. Richardson *et al* reported patients in the New York City area with hypertension, obesity and diabetes to be at high risk of death from COVID-19.<sup>12</sup> In the UK and Italy, COVID-19 deaths have been mainly observed among older male patients with multiple comorbidities.<sup>13,14</sup> A higher burden of comorbidities, male sex and older age may be considered more substantial determinants of higher risk of death in Italy than in China.<sup>15</sup> These studies indicate that health disparities and socioeconomic status seem to be important for COVID-19 infection in six high-income countries. These characteristics are aligned with demographic and epidemiological features in those countries.

As the pandemic spreads across the world, developing countries appear to be the disease's next target.<sup>16</sup> The outbreak could devastate parts of those countries as they differ from wealthier countries in terms of demographic composition, the sources of people's livelihoods and health system capacity. COVID-19 mitigation interventions applied in high-income countries may not fit developing countries. For example, as the largest numbers of deaths in high-income countries are taking place among older people, public health mitigation is focusing on care home mitigation and social care resilience strategies. With their younger populations, developing countries may consider different mitigation strategies. Hence, identifying social determinants of health and inequalities around COVID-19 infections and deaths in developing countries is very important for public health mitigation strategies.

Indonesia is a developing country and home to the world's fourth-largest population and second-largest

urban area. With its huge population and weak health-care system, some scholars and analysts predict that the country could be the next COVID-19 hot spot in Asia.<sup>16–18</sup>

Currently, the WHO is reporting that Indonesia has the highest rate of COVID-19 infection and death among ASEAN (Association of Southeast Asian Nations) countries.<sup>17,19</sup> The number of COVID-19 cases has increased sharply each day since April 2020. As of 17 August 2021, as many as 4008 166 cases have been officially confirmed in the country, with 128 252 deaths recorded thus far. The virus has spread to all of the country's 34 provinces. Java Island is the epicentre, with East Java and Jakarta, the country's largest region and its capital city, respectively, as the most densely infected areas. The number of total PCR tests in the country is low at 26 275 tests per million individuals;<sup>19</sup> it is therefore probable that the actual number of infections is higher than the central government's officially reported number. It is also expected that the number of cases will continue to increase as the government eases restrictions under the 'new normal policy' in effect since the beginning of June 2020. With limited medical staff, hospital beds and intensive care facilities as well as a lack of government (especially local government) capacity to provide COVID-19 treatments and medications, early prevention and mitigation are particularly crucial in rural areas, where the deficit of COVID-19 health facilities and workers is significant. Densities of doctors and nurses in Indonesia, at 3.9 doctors per 10 000 population and 13.8 nurses per 10 000 in 2020, are the second lowest among south-east Asian countries.<sup>20</sup> The number of hospital beds per 1000 population is 1.1, which is lower than the WHO requirement (a minimum of 3 beds per 1000 population).<sup>21</sup>

Ranscombe recently highlighted the need to take a systematic approach to tackling the COVID-19 crisis, focusing on rural areas.<sup>22</sup> He posited that the adoption of a systematic approach should include examining the sociomedical, socioeconomic and sociopolitical implications of confronting the pandemic in rural areas, which often have a significant scarcity of health facilities and workers for COVID-19 treatment as well as insufficient knowledge about COVID-19 infection. Accordingly, studies have shown limited healthcare access in rural Indonesia as a key factor of citizens' health and well-being.<sup>22–24</sup> Various community-based healthcare interventions which play a vital role in improving individual health status exist within villages.<sup>25–28</sup> Poverty is a major characteristic of Indonesia's rural population, and it partially determines citizens' health status.<sup>23</sup> The village community is also a place of indigenous sociocultural activities as such activities may increase transmission of COVID-19 in rural areas.<sup>29–31</sup> Such activities may directly mediate COVID-19 infection within and between villages as most villagers are culturally obliged to take part in them.

Hence, this study aims to examine whether those socio-demographic characteristics and healthcare access are associated with COVID-19 infection and death in rural Indonesia. By identifying the most vulnerable group based



**Figure 1** Malang District East Java Indonesia.

on sociodemographic characteristics and health access, better targeting of local health services for COVID-19 prevention and treatment can be achieved within communities. It is vital to identify the most important social and health access determinants associated with COVID-19 infection and morbidity to guide policymakers in formulating more focused mitigation strategies.

## METHODS

### Study design and settings

This study used a non-random cross-sectional design based on official COVID-19 tracing data collected by the Malang District Health Authority (DHA) from 1 March to 29 July 2020, and administrative data from 390 villages retrieved from Indonesia's Village Potential Census 2020 (PODES).<sup>32</sup> This study was conducted in Malang District in East Java, Indonesia. Malang is located quite close to the city of Surabaya, which is currently the biggest COVID-19 epicentre in Indonesia (figure 1).

Malang's area covers 3535 square kilometres, with an agricultural emphasis on rice and sugar cane. Malang's total population of 2544 315 is distributed across 33 subdistricts, 390 villages and 3125 community neighbourhoods.<sup>33</sup> A subdistrict consists of villages, and a village consists of community neighbourhoods. The number of people in each village and community neighbourhood in Malang District averages 6400 and 746, respectively.<sup>33</sup>

### Data sources

#### COVID-19 contact tracing data

COVID-19 contact tracing data were collected by the Malang DHA based on the Indonesian Ministry of Health COVID-19 prevention and control guidelines. Formal permission was given by the authority to analyse the data. The total number of individuals traced from 1 March to 29 July 2020, was 14 264. The tracing data covered the entire population of Malang District (2544 315 individuals). COVID-19 contact tracing refers to the process of identifying all individuals who fulfil one of these criteria: (1) Having had contact with a patient with confirmed

COVID-19 within the previous 2 weeks, (2) Having one of the COVID-19 symptoms, or (3) Having travelled from one of the COVID-19 epicentre areas in Indonesia or abroad.<sup>34</sup> Close contact was identified by health workers in each village using the following criteria: those living in the same household with or having been close to someone who had tested positive for COVID-19.<sup>34</sup>

The tracing was organised by the Malang DHA based on the Ministry of Health surveillance guidelines for SARS-CoV-2 infection (see online supplemental materials). Written informed consent was obtained by the Malang DHA from all individuals before data collection. Prior to interviewing, individuals were informed about the importance of participating in the contact tracing activities. Confidentiality and anonymity were ensured.<sup>35</sup> Malang contact tracers were selected by the Ministry of Health COVID-19 task force through recommendations from the provincial and DHA team. Overall, 78 medical doctors and 780 nurses across 39 primary healthcare centres (*Pusat Kesehatan Masyarakat* or *Puskesmas*), supporting primary healthcare centres (*Puskesmas Pembantu*) and 390 village health posts (*Pondok Kesehatan Desa* or *Ponkesdes*) were involved in tracing services in Malang District. All recruited contact tracers underwent a thorough 3-day training to learn and practise methods of detection, prevention, response and control for COVID-19 risk communication and COVID-19 case management. Thirty-nine additional Malang DHA staff members worked to facilitate the logging and cataloguing of data, coordinating logistics and checking the quality of filled COVID-19 surveillance forms.

During data collection, the tracing team members were equipped with several items of personal protective equipment for public screening, including hazardous material suits (Kodaichi Coverall), medical masks (N95 3M Type 9010), face shields (headgear with clear visor), surgical gloves (Golden Glove latex), boots or closed work shoes, and hand sanitiser. They were also instructed to carry an infrared thermometer (KODYEE CF-818) as well as the COVID-19 surveillance and monitoring forms provided

by the DHA. Interviews with individuals suspected of carrying COVID-19 were conducted at a distance of 1.5–3 m.<sup>36</sup>

Contact tracing was conducted in several venues, but most interviews with individuals suspected of meeting one of the three criteria above were conducted via home visit/door-to-door tracing. Based on the reports, the contact tracing team created lists of triaged contacts for further assignment. All individuals on the contact lists were notified by the contact tracing team before the team interviewed them at their homes or at secure locations such as a *Ponkesdes* office. Subsequently, nurses in each village were responsible for monitoring all contacts to which individual nurses were assigned for at least 14 days. In addition, the team conducted COVID-19 tracing in several public places including bus stations, train stations, the local airport and other public gathering places to track people travelling from other cities or abroad.

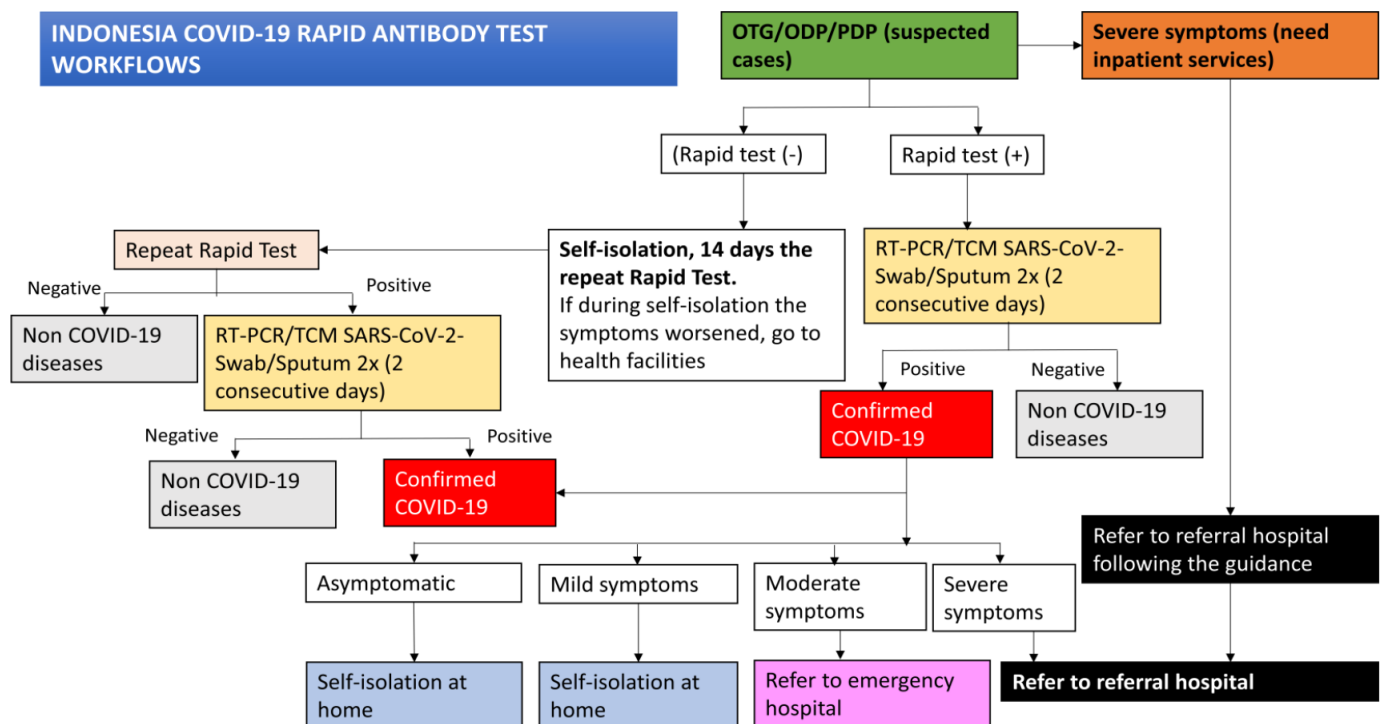
The team referred patients with severe COVID-19 symptoms requiring inpatient services to a COVID-19 referral hospital. Patients received a repeat Reverse Transcription Polymerase Chain Reaction (RT-PCR) swab test at the hospital. Patients with only mild or no symptoms were tested using a rapid test. If the result of this first rapid test was negative, the patient was asked to self-isolate for 14 days and take another rapid test at the end of the self-isolation period. A second negative result on a rapid test showed that the individual was likely not infected at the time. Patients receiving a positive result from the second rapid test were required to undergo two RT-PCR swab tests on two consecutive days. If the RT-PCR swab test result was negative, an individual was likely not

infected at the time. A positive result on an RT-PCR swab test confirmed COVID-19 infection, and patients were required to take protective steps to prevent others from becoming infected. If the first rapid test showed positive results, the patient was required to undergo two RT-PCR swab tests on two consecutive days. If the RT-PCR swab test result was negative, the individual was likely not infected at the time. If the RT-PCR swab test result was positive, the individual was required to take protective steps to prevent others from becoming infected. Patients with confirmed COVID-19 with mild or no symptoms were permitted to self-isolate at home, while those with moderate or severe symptoms were referred to hospitals. Patients with a positive rapid test but a negative RT-PCR swab test were not required to self-isolate. The procedures for COVID-19 tracing and testing are explained in the supporting information in figure 2.

The Malang DHA provided a form to record information on every individual who died due to COVID-19. Mortality data were collected by all public and private hospitals in Malang District. Mortality data on individuals who died outside health facilities were collected by the village nurses on the forms provided. The Malang DHA recorded the cause of death for every individual who died due to COVID-19 on the medical death certificate. The authority's elapsed time to obtain information on deaths due to COVID-19 was 14 days.<sup>34–36</sup>

#### Indonesia's PODES data

We merged the contact tracing data with administrative data from 390 villages retrieved from Indonesia's PODES.<sup>33</sup> The PODES represents a long-standing tradition of



**Figure 2** Procedure for COVID-19 tracing and testing. ODP, Orang Dalam Pemantauan; OTG, Orang Tanpa Gejala; PDP, Pasien Dalam Pengawasan; RT-PCR, reverse transcription PCR; TCM, Test Cepat Molekuler



collecting data at the lowest administrative tier of local government. PODES consists of 83 931 villages (*desa*) across 514 districts in Indonesia. The census has been conducted every 2 years since 1983 by the Indonesian Central Bureau of Statistics (*Biro Pusat Statistik*). Detailed information was gathered on a range of characteristics from public infrastructure to village finances. Information was gathered from *kepala desa* (rural village heads) and *lurah* (urban neighbourhood heads). From the 2020 census, we retrieved the following data for each village: number of health workers, number of community-based healthcare interventions and number of indigenous sociocultural activities as well as hospital access, poverty and distance to a COVID-19 epicentre city.<sup>32</sup>

### Variables

The outcome variables in this study are COVID-19 infections and COVID-19 deaths. RT-PCR swab tests are used by the Malang DHA to determine the presence of COVID-19 infection. The authority determines that an individual is infected if the RT-PCR swab test shows a positive result. The Indonesian Ministry of Health follows the WHO definition of death due to COVID-19 as a 'death resulting from a clinically compatible illness, in a probable or confirmed COVID-19 case, unless there is a clear alternative cause of death that cannot be related to COVID-19' (eg, traffic accident or trauma).<sup>36–38</sup> Deaths due to COVID-19 cannot be attributed to another disease (eg, cancer) and are counted independent of pre-existing conditions suspected of triggering a severe case of COVID-19 (eg, coronary artery disease, type 2 diabetes or chronic obstructive pulmonary disease (COPD)).

Marmot and Wilkinson, Tian *et al*<sup>4</sup> and WHO define social determinants of health as the conditions in which people are born, grow, live, work and age.<sup>39–40</sup> They include determinants such as socioeconomic status, education, neighbourhood and physical environment, employment status, and social support networks, as well as access to healthcare. In this study, we used job type, number of community-based health interventions, village poverty, number of indigenous sociocultural activities, distance to a COVID-19 referral hospital and distance to a COVID-19 epicentre city to investigate sociodemographic characteristics and health access.

Job types were divided into nine categories: health workers, civil servant non-health workers (ie, teachers, village and district government staff, police, army and other civil servants providing direct community service during the pandemic), labourers (ie, factory workers or construction workers), professional workers (ie, bank staff or company staff), traders, farmers, housewives, students and retired persons. We used health workers as the reference group as this group is among those with the highest risk for COVID-19 infection and death.

Previous studies have documented that village poverty status and the number of community-based healthcare interventions are linked with individual health status and well-being.<sup>41–43</sup> We therefore wanted to examine whether

these determinants were associated with COVID-19 infection and mortality. In this study, we used government Central Bureau of Statistics data for village poverty. The Malang Central Bureau of Statistics authority follows the national guideline for measuring poverty, which is based on \$3.20 a day purchasing power parity, corresponding to conditions in lower-middle-income countries.<sup>33</sup> The authority provides data on the ratio of families living below the poverty line in all 390 villages.

Community-based healthcare interventions refer to neighbourhood or community activities aiming to provide healthcare support within a community.<sup>26–28</sup> In Malang, such interventions are conducted by voluntary health workers or *kader* in *Posbindu* (*Pos pembinaan terpadu* or integrated health posts for Non Communicable Diseases (NCDs)) and *Posyandu/Posyandu Lansia* (*Pos pelayanan terpadu lanjut usia* or integrated healthcare service posts for children and older people), which play a vital role in improving individual health status within villages.<sup>28</sup>

In this study, community-based healthcare data were retrieved from the PODES 2020 census. In the census, the number of community-based healthcare interventions was measured by the number of *Posbindu* and *Posyandu/Posyandu Lansia* in each village. During the outbreak, these community-based healthcare interventions were important for supporting district governments in increasing COVID-19 awareness among villagers. The district governments authorised health cadres at *Posbindu* and *Posyandu/Posyandu Lansia* to serve as community COVID-19 task force teams responsible for monitoring persons suspected of infection and disseminating COVID-19 early mitigation strategies.

We also included indigenous sociocultural activities as such activities may increase transmission of COVID-19 in rural areas. Indigenous sociocultural activities refer to native communal activities such as Javanese wedding ceremonies (*mantenan*), Javanese traditional circumcision ceremonies (*khitan*), traditional birth celebrations (*tasyakuran melahirkan*), religious meetings (*pengajian*), the obligation to visit and attend to sick or dying neighbours (*mbesuk* or *melayat*) and other communal activities that form part of rural Javanese traditional cultures.<sup>29–31</sup> The PODES 2020 measured these activities as the number of sociocultural activities in each village per month. Such activities may directly mediate COVID-19 infection within and between villages as most villagers are culturally obliged to take part in them.

Distance to a COVID-19 epicentre city was measured as the distance of each village from an epicentre city in kilometres. To capture whether healthcare access may be linked to COVID-19 patients' odds of dying from the disease, we included the total number of health workers and the distance of each village to a COVID-19 referral hospital. The number of indigenous sociocultural activities and the distance to a COVID-19 epicentre city was included to measure risk of COVID-19 infection.<sup>32</sup>

Other individual sociodemographic and medical characteristics related to COVID-19 infection and death were

also included, such as age, sex, the presence of COVID-19 symptoms, having had contact with individuals with confirmed or suspected cases of COVID-19, the presence of comorbidities, medical diagnosis before RT-PCR, inpatient treatment, and intensive care unit treatment. Age was categorised into four groups based on Indonesia's demographic groups: 17 years and younger, 18–44 years, 45–60 years, and 61 years and older. Among people with confirmed cases, we include whether respondents had symptoms such as fever, cough, runny nose, sore throat, shortness of breath, shivering, headache, fatigue, muscle aches, nausea, abdominal pain or diarrhoea. We also asked whether respondents had had contact with people with confirmed COVID-19 cases, had had contact with people suspected of being infected with COVID-19, or had visited an animal market in the previous 2 weeks. Among patients who died of COVID-19, we included comorbidities through history of diabetes, cardiovascular diseases, hypertension, autoimmune diseases and kidney diseases. We also included pre-RT-PCR test diagnosis of pneumonia, COPD and respiratory failure by a medical doctor. Individuals receiving COVID-19 hospital inpatient services and hospital intensive care unit services were also included to control for COVID-19 deaths. The data set for the study are available online at Zenodo Repository.<sup>33</sup>

### Ethical clearance, patient and public involvement

The review board certified that all procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration. Neither patients nor the public were involved in the design or conduct of this study. Participants did not contribute to the writing or editing of this manuscript. The authority sought and received informed written consent from each participant or family members in some cases if the patients might have been alive but intubated or otherwise incapable of giving permission themselves before the interview.

### Statistical methods

Multilevel or hierarchical regression analyses were applied to take full advantage of the village clustering information available from the data. These regression analyses are able to account for the clustering of individuals by separating individual variances of COVID-19 infections and COVID-19 deaths from village variances. This type of regression is therefore more appropriate than simple regression, which does not take village-level clustering data into account. For these analyses, hierarchical logistic regression was used to estimate factors associated with COVID-19 infection and COVID-19 mortality. The mathematical formula for both models can be written as follows, considering an individual  $i$  nested in a village  $j$ :

$$E_{ij*} = \beta_0 + \sum \beta_j W_j + \beta_{ij} X_{ij} + \mu_j + \epsilon_{ij}$$

With:

$E_{ij*} = \text{logit}(P(E_{ij*} = 1 \text{ or } 0))$  as a binary variable indicating an individual who has been infected with or died

from COVID-19 (ie, 1=COVID-19 infection or death; 0=No)

$W_j$  as a set of village determinants ( $j$ =number of community-based healthcare interventions, number of indigenous sociocultural activities, village poverty, distance to a COVID-19 epicentre city, number of health workers and distance from village to a COVID-19 referral hospital)

$X_{ij}$  as a set of individual determinants ( $i$ =age, sex, job type, symptoms, comorbidities, etc)

$\mu_j$  as a random intercept of villages with mean zero and variance  $\sigma_\mu^2$ .

$\epsilon_{ij}$  normally distributed with zero and variance  $\sigma_\epsilon^2$ .

We estimated a hierarchical logit model using multilevel mixed-effects logistic regression (*melogit*). In this study, *melogit* fits mixed-effects models for binary responses. The conditional distribution of the response given the random effects is assumed to be Bernoulli distribution, with success probability determined by the logistic cumulative distribution function. We used maximum likelihood estimation to fit all models. ORs were used to compare the magnitude of each social determinant of health for individual COVID-19 infections and deaths. We carried out two-level logistic regression using STATA V.16.0 software.

## RESULTS

### Characteristics of the sample

**Table 1** presents the characteristics of the sample in this study, which is divided into two categories: all COVID-19 contact traced individuals ( $n=14\,264$ ) and individuals confirmed infected with COVID-19 ( $n=551$ ). We found that 4% ( $n=551$ ) of tracked individuals were confirmed infected, and 11% ( $n=62$ ) of those infected individuals died. Most of the tracked and infected individuals were male (64% and 53%, respectively). Most were young adults (18–44 years) and middle-aged adults (45–60 years), and most were labourers and traders who regularly worked in epicentre cities, that is, Malang City or Surabaya City. Among those who were infected, 29% reported having contact with individuals with confirmed COVID-19 cases, and 17% reported having had contact with individuals with suspected COVID-19 cases. Fever, cough and shortness of breath were the most common symptoms among those with confirmed cases of COVID-19 (39%, 32% and 27%, respectively). We found that 13% of infected individuals had at least one symptom, while 46% of those who died of COVID-19 had reported having at least one symptom. Among traced individuals, 23% and 14% reported having hypertension and diabetes, respectively. Of those who died of COVID-19, 60% and 49% had reported having hypertension and diabetes. Almost half of the infected patients (40%) were diagnosed as having pneumonia, and a small percentage were diagnosed as having acute respiratory distress syndrome and/or respiratory failure. Half of the infected individuals reported receiving inpatient treatment at a hospital. The number of community-based healthcare interventions varied

**Table 1** Sample characteristics of all tracked individuals and COVID-19 confirmed cases

Variables	All sample (n=14 264)				COVID-19 confirmed cases (n=551)			
	% or mean	SD	Min	Max	% or mean	SD	Min	Max
COVID-19 infections	551 (3.9%)				551 (100%)			
COVID-19 deaths	62 (0.4%)				62 (11.3%)			
Male	9109 (63.9%)				293 (53.2%)			
Age, years								
≤17	1794 (12.6%)				33 (6.0%)			
18–44	9049 (63.6%)				218 (39.6%)			
45–60	2766 (19.4%)				214 (38.8%)			
>60	632 (4.4%)				86 (15.6%)			
Job type								
Civil servant, non-health worker	62 (0.4%)				14 (2.5%)			
Health worker	58 (0.4%)				12 (2.2%)			
Professional worker	59 (0.4%)				5 (0.9%)			
Labourer	4092 (28.7%)				347 (63.0%)			
Trader	2349 (16.5%)				295 (53.5%)			
Farmer	2265 (15.9%)				37 (6.7%)			
Housewife	2085 (14.6%)				170 (30.9%)			
Student	2864 (20.0%)				42 (7.6%)			
Retired	227 (1.6%)				25 (4.5%)			
Had contact with confirmed COVID-19 case	512 (3.6%)				159 (28.9%)			
Had contact with suspected COVID-19 case	354 (2.5%)				92 (16.7%)			
Visited animal market	14 (0.1%)				1 (0.2%)			
Symptoms								
Fever	983 (6.9%)				212 (38.5%)			
Cough	1200 (8.4%)				178 (32.3%)			
Runny nose	549 (3.8%)				58 (10.5%)			
Sore throat	288 (2.0%)				40 (7.3%)			
Shortness of breath	640 (4.5%)				147 (26.7%)			
Shivering	121 (0.8%)				17 (3.1%)			
Headache	180 (1.3%)				30 (5.4%)			
Fatigue	457 (3.2%)				76 (13.8%)			
Muscle aches	133 (0.9%)				21 (3.8%)			
Nausea	241 (1.7%)				55 (10.0%)			
Abdominal pain	113 (0.8%)				20 (3.6%)			
Diarrhoea	68 (0.5%)				14 (2.5%)			
Having at least one symptom	1824 (12.8%)				299 (45.7%)			
Presence of comorbidities								
Diabetes	2026 (14.2%)				267 (48.5%)			
Heart diseases	80 (0.6%)				8 (1.5%)			
Hypertension	3213 (22.5%)				333 (60.4%)			
Chronic kidney diseases	19 (0.1%)				4 (0.7%)			
Autoimmune diseases	15 (0.1%)				2 (0.4%)			
Chronic obstructive pulmonary disease	32 (0.2%)				4 (0.7%)			
Medical doctor diagnosis before RT-PCR								

Continued

**Table 1** Continued

Variables	All sample (n=14 264)				COVID-19 confirmed cases (n=551)			
	% or mean	SD	Min	Max	% or mean	SD	Min	Max
Pneumonia	648 (4.5%)				222 (40.3%)			
Acute respiratory distress syndrome	23 (0.2%)				7 (1.3%)			
Respiratory failure	0.8%				11 (2.0%)			
Inpatient	5.8%				276 (50.1%)			
intensive care unit	0.2%				6 (1.4%)			
Village determinants								
Number of community-based health interventions	134	20	0	149	111	41	0	147
Number of indigenous sociocultural activities	11	5	3	32	14	6	4	32
Distance to a COVID-19 referral hospital (km)	10	9.1	0.0	43.0	3.9	4.6	0.0	36.5
Number of health workers	8	9	0	69	13	14	1	69
Village poverty	0.2	0.04	0.01	0.4	0.2	0.05	0.03	0.3
Distance to a COVID-19 epicentre city (km)	34.2	16.0	1.0	79.0	18.8	10.0	4.0	68.0
N (villages)	390				152			

RT-PCR, reverse transcription PCR.

across the 390 villages, ranging from 0 to 149. Likewise, the number of indigenous sociocultural activities varied, with an average of 11 activities in each village. On average, the distance from a village to an epicentre city (Malang or Surabaya) was 34 km, while the average distance to a COVID-19 referral hospital was approximately 11 km. The average number of health workers in each village was eight, while the average proportion of people living in poverty was 20% across all villages.

Figures 3 and 4 describe the distribution of COVID-19 infections and COVID-19 deaths across 390 villages in the district. In terms of COVID-19 infections, the number of infected individuals was larger in villages closer to a COVID-19 epicentre.

### Multilevel logistic results for COVID-19 infection

Table 2 shows the multivariate ORs for the effects of individual and village-level determinants on COVID-19 infection. The unadjusted OR of COVID-19 infection shows that being older was associated with a higher risk of infection. However, the associations were not statistically significant after adjusting for socioeconomic and health variables at the individual and village levels. Male respondents had an approximately 30% lower risk (95% CI 0.57 to 0.85) of COVID-19 infection in the unadjusted model. The association remained statistically significant in the fully adjusted model. Also in the fully adjusted model, students and retirees had 83% and 78% lower probability, respectively, of having COVID-19 than health workers. Traders and housewives had higher odds of contracting COVID-19 in the unadjusted model, but those relationships disappeared in the fully adjusted model.

Contact history with patients with confirmed COVID-19 was associated with an increased risk of contracting

COVID-19 (unadjusted OR 12.98, 95% CI 9.36 to 18.00). This effect remained stable after adjusting for other risk factors. Respondents with a history of contact with suspected COVID-19 patients and those having visited an animal market had 5.19 times and 1.06 times higher risk, respectively, in the unadjusted model, but these associations disappeared in the fully adjusted model.

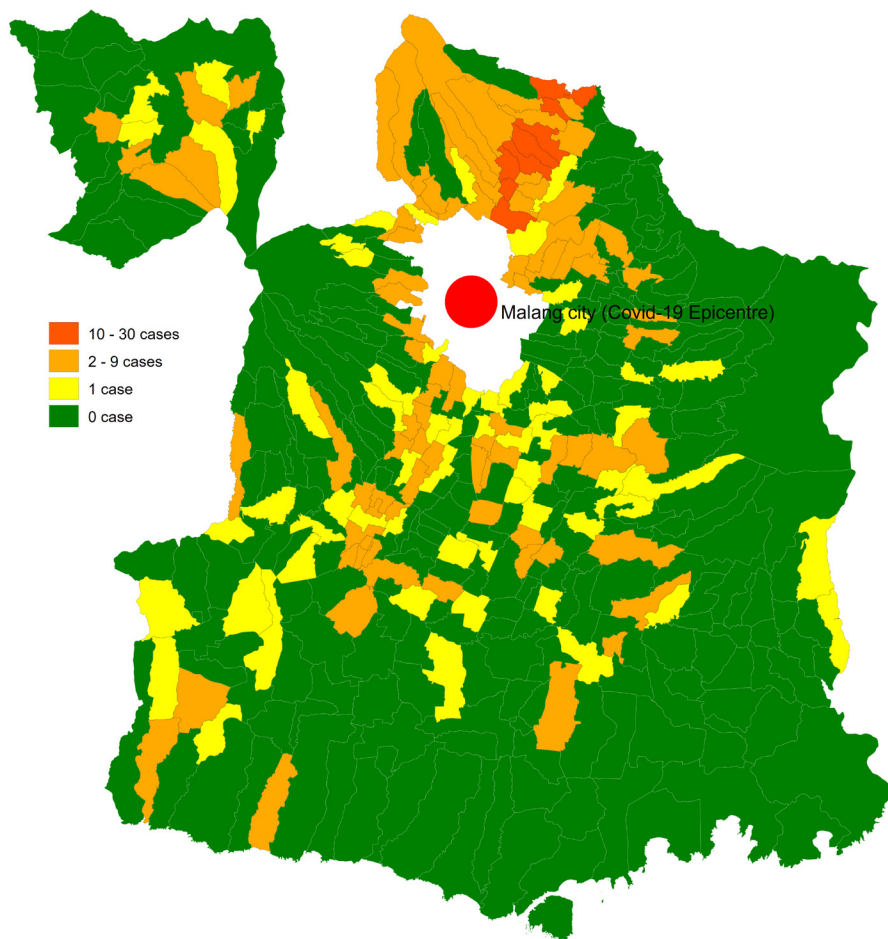
Fever and difficulty breathing were associated with 2.59 (95% CI 2.04 to 3.29) and 2.27 times higher risk (95% CI 1.74 to 2.96) of having COVID-19, respectively, in the unadjusted model. These associations remained in the fully adjusted model. Hypertension (adjusted OR 4.36, 95% CI 2.76 to 6.88) showed a positive and significant association with a higher risk of COVID-19 infection, while respondents with heart disease had an 84% lower risk of COVID-19 infection (95% CI 0.07 to 0.40).

Turning to the village-level determinants, a greater number of community-based health interventions (adjusted OR 0.99, 95% CI 0.98 to 1.00) and greater distance to a COVID-19 epicentre city (adjusted OR 0.94, 95% CI 0.92 to 0.96) were related to a lower risk of COVID-19 infection. A greater number of indigenous sociocultural activities (unadjusted OR 1.11, 95% CI 1.05 to 1.17) and living in a poor village (adjusted OR 3.30, 95% CI 1.27 to 8.56) were associated with a higher risk of COVID-19 infection. However, adjusting for individual and other village-level covariates eliminated the effects of both indigenous sociocultural activities and living in a poor village on COVID-19 infection. The Intra Class Correlation (ICC) of 0.37 indicates that 37% of the variation in COVID-19 infection was located in villages.

### Multilevel logistic results for COVID-19 mortality

Table 3 presents the analysis of COVID-19 mortality among the confirmed cases. The odds of dying of





**Figure 3** Distribution of COVID-19 infections in 390 villages of Malang District, East Java, Indonesia, 29 July 2020.

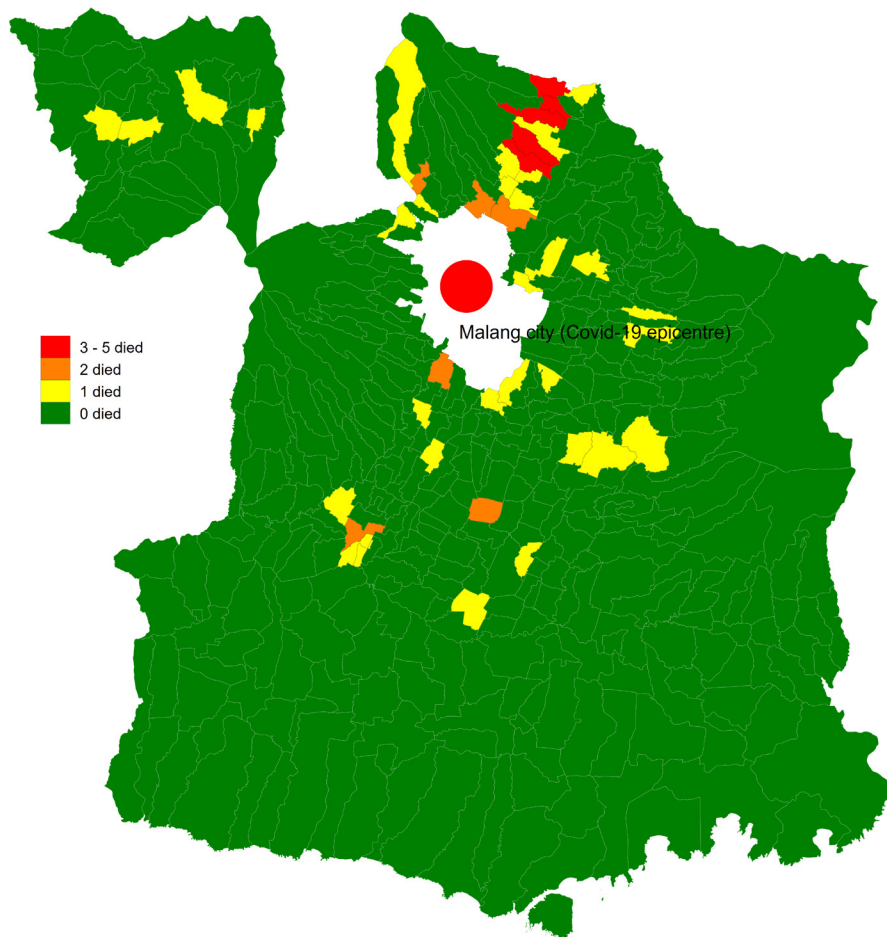
COVID-19 were higher among respondents aged 61 years and older (adjusted OR for age group 61 years and older 364.22, 95% CI 88.57 to 1497.70). Working as a professional worker or labourer was associated with decreased COVID-19 mortality in the fully adjusted model. Respondents with diabetes, hypertension and COPD had higher odds of COVID-19 mortality. However, this association was only found in the unadjusted model. In the adjusted model, we found that respondents with hypertension had 17.1 times higher odds of COVID-19 mortality.

Respondents who received inpatient and intensive care unit treatment had 30.48 times and 12.03 times higher odds of COVID-19 mortality, respectively. Respondents diagnosed by health professionals as having pneumonia and acute respiratory distress syndrome had 4.75 times and 5.99 times higher odds of COVID-19 mortality after adjusting for other individual and village-level covariates. The number of community-based healthcare interventions was significantly associated with lower COVID-19 mortality (adjusted OR 0.98, 95% CI 0.97 to 1.00). Living near a COVID-19 referral hospital was associated with a lower risk of COVID-19 mortality (adjusted OR 1.45, 95% CI 1.02 to 1.51). The ICC is very small ( $2.48 \times 10^{-34}$ ), indicating that variation between villages provides little explanation of COVID-19 mortality.

## DISCUSSION

Using official government contact tracing data from Malang District, East Java, Indonesia, this study identifies sociodemographic characteristics and health access that are associated with COVID-19 infection and mortality. We found that women, individuals having had direct contact with people with confirmed COVID-19 cases, individuals with fever and difficulty breathing, and individuals with hypertension constitute the groups most vulnerable to COVID-19 infection. In contrast with earlier studies in Wuhan, China, which reported visitors to and workers at seafood and wet animal wholesale markets as being at high risk, we did not find individuals who visited animal markets to be at increased risk for infection.<sup>3</sup> We did, however, find individuals having had close contact with patients with confirmed COVID-19 to be at higher risk of infection. Retired individuals and students had lower risk of COVID-19 infection than health workers. As school was in session only online, students may have had less social contact than others. Similarly, retired individuals tend to socialise less than other people. These findings confirm earlier studies in China and other countries which found that health workers are at higher risk of infection.<sup>4 42</sup>

Among respondents with confirmed COVID-19 cases, we found that men, individuals aged 61 years and older,



**Figure 4** Distribution of COVID-19 mortality in 390 villages of Malang District, East Java, Indonesia, 29 July 2020.

individuals with hypertension, and those diagnosed with pneumonia and respiratory failure were at higher risk of death. The demographic pattern of COVID-19 deaths in Malang seems similar to patterns in previous findings which reported that larger proportions of deaths were found among members of older age groups.<sup>2</sup> Accordingly, we found men and those with a history of hypertension to be at higher risk of death. In fact, the rate of death due to hypertension in Malang is very high. One plausible explanation for this is the prevalence of undetected cardiometabolic conditions in Indonesia: through our work in 2014 and 2018, we discovered that more than two-thirds of Indonesian adults aged 40 years and older have unmet needs for cardiovascular care.<sup>7-9</sup> Moreover, we found a higher risk of COVID-19 infection among individuals with hypertension. As conveyed in prior studies and government reports, hypertension is quite common among older adults in Indonesia.<sup>43-45</sup> Hence, the elevated likelihood of COVID-19 infection among individuals with hypertension may be linked to the high proportion of adult Indonesians with hypertension. Accordingly, patients diagnosed with pneumonia and respiratory failure had a higher likelihood of dying of COVID-19 than others. Previous studies have reported that pneumonia and respiratory failure may indicate COVID-19 as the infection may result in severe pneumonia and respiratory failure.<sup>46-49</sup>

Confirming previous studies, we found that the only symptoms associated with COVID-19 infection were fever and shortness of breath. There was null association with other symptoms. These findings are consistent with earlier studies in China and developed countries, which have also shown that fever and shortness of breath are common symptoms associated with COVID-19 infection.<sup>7,50</sup> Accordingly, we found that about half of infected individuals had at least one symptom, while other infected individuals reported no symptoms. These results match those of prior studies, which found a high ratio of asymptomatic COVID-19 infection.<sup>4, 51</sup> Given this ratio, prevention of COVID-19 infection in the district will prove challenging as villagers generally still have little awareness of the virus.

The pattern of the pandemic spread is reflected in our finding that greater distance to a COVID-19 epicentre is associated with a lower risk of infection. This appears, also in Malang District, to follow the pattern of regional economic growth concentrated in urban areas and cities.<sup>52-55</sup> As centres for business and economic activities, urban areas and cities are places where large numbers of people work, shop and sell agricultural products. As there were fewer restrictions on human mobility in Malang early in the pandemic, the virus spread first to neighbouring villages around the epicentre and then moved to more remote areas. Hence, people living near epicentre cities,

**Table 2** Unadjusted and adjusted multilevel logistic regressions for COVID-19 infection (N<sub>individual</sub> = 14 264, N<sub>village</sub> = 152)

Variables	Unadjusted OR	95% CI	P value	Adjusted OR	95% CI	P value
Individual determinants						
Age, years, reference: 17 years and younger						
18–44	2.09	1.39 to 3.15	<0.001	0.83	0.36 to 1.95	0.673
45–60	5.05	3.33 to 7.66	<0.001	1.02	0.41 to 2.55	0.968
61 years and older	5.36	3.34 to 8.63	<0.001	1.14	0.43 to 3.03	0.799
Male	0.70	0.57 to 0.85	<0.001	0.74	0.56 to 0.98	0.033
Job type, reference: health worker						
Civil servant, non-health worker	9.30	3.93 to 22.00	<0.001	6.09	0.44 to 85.18	0.180
Professional worker	0.45	0.16 to 1.23	0.122	0.37	0.05 to 2.76	0.330
Labourer	1.17	0.80 to 1.71	0.413	0.42	0.13 to 1.38	0.153
Trader	1.51	1.03 to 2.21	0.032	0.39	0.12 to 1.26	0.115
Farmer	1.45	0.94 to 2.22	0.086	0.37	0.11 to 1.27	0.113
Housewife	1.87	1.47 to 2.38	<0.001	0.42	0.13 to 1.38	0.153
Student	0.32	0.23 to 0.44	0.000	0.17	0.05 to 0.66	0.011
Retired	3.18	2.08 to 4.86	0.000	0.22	0.06 to 0.81	0.023
Had contact with confirmed COVID-19 cases	12.98	9.36 to 18.00	<0.001	20.56	12.96 to 32.62	0.000
Had contact with suspected COVID-19 cases	5.19	3.63 to 7.43	<0.001	0.86	0.51 to 1.47	0.583
Visited animal market	1.06	0.09 to 11.85	0.960	0.10	0.01 to 1.23	0.072
Symptoms						
Fever	2.59	2.04 to 3.29	<0.001	2.68	1.95 to 3.71	0.000
Cough	1.02	0.80 to 1.31	0.823	0.85	0.58 to 1.23	0.386
Runny nose	0.59	0.42 to 0.83	0.003	0.80	0.51 to 1.27	0.343
Sore throat	0.83	0.55 to 1.24	0.382	0.78	0.46 to 1.30	0.334
Difficulty breathing	2.27	1.74 to 2.96	<0.001	3.03	2.11 to 4.36	0.000
Shivering	0.97	0.53 to 1.80	0.948	0.58	0.27 to 1.25	0.165
Headache	1.58	0.97 to 2.58	0.062	1.26	0.70 to 2.27	0.439
Fatigue	1.81	1.30 to 2.50	<0.001	0.72	0.47 to 1.12	0.151
Muscle aches	1.60	0.88 to 2.88	0.118	0.89	0.43 to 1.85	0.758
Nausea	2.09	1.42 to 3.07	<0.001	1.54	0.93 to 2.56	0.091
Abdominal pain	1.20	0.67 to 2.15	0.531	0.73	0.35 to 1.55	0.414
Diarrhoea	2.11	1.01 to 4.37	0.044	1.83	0.76 to 4.42	0.180
Presence of comorbidities						
Diabetes	4.98	3.98 to 6.24	<0.001	1.08	0.68 to 1.72	0.749
Heart diseases	0.41	0.18 to 0.92	0.031	0.16	0.07 to 0.40	0.000
Hypertension	5.65	4.51 to 7.10	<0.001	4.36	2.76 to 6.88	0.000
Autoimmune diseases	7.02	0.98 to 50.13	0.052	4.06	0.65 to 25.13	0.132
Chronic obstructive pulmonary disease	5.08	1.32 to 19.44	0.018	0.43	0.08 to 2.40	0.337
Village determinants						
Number of community-based healthcare interventions	0.96	0.95 to 0.98	<0.001	0.99	0.98 to 1.00	0.008
Number of indigenous sociocultural activities	1.11	1.05 to 1.17	<0.001	1.03	0.99 to 1.08	0.156

Continued

Table 2 Continued

Variables	Unadjusted OR	95% CI	P value	Adjusted OR	95% CI	P value
Village poverty status	3.30	1.27 to 8.56	0.014	14.86	0.21 to 10.75	0.216
Distance to COVID-19 epicentre city	0.91	0.89 to 0.93	<0.001	0.94	0.92 to 0.96	0.000
ICC				0.37	0.28 to 0.46	
Likelihood				-1346.11		
ICC, Intra Class Correlation.						

who have more frequent contacts and thus more exposure to the virus, have a higher risk of infection than rural people who live far from epicentres, have fewer contacts with village outsiders, and therefore have less exposure to the virus.

As documented in several studies, the characteristics of healthcare system development in Indonesia follow the pattern of regional economic development, which is biased towards urban areas and cities.<sup>56–59</sup> COVID-19 referral hospitals in Indonesia, including in Malang, are concentrated in city centres and are more likely to have a larger number of specialised medical doctors and better hospital facilities. For example, most hospitals in Malang City have more isolation rooms and ventilators than those in Malang District. Malang District has four COVID-19 referral hospitals with a total of 126 isolation rooms. All of these hospitals are located in *Kepanjen* and *Gondanglegi* subdistricts as the central areas of Malang District.

Rural residents who live in other subdistricts must travel approximately 2–3 hours to reach those hospitals. With very limited transportation available during the outbreak, infected villagers often were not taken to hospitals or were taken when already in a critical condition, placing them at higher risk of death. On the other hand, villagers who lived near a referral hospital were able to obtain medical treatment more quickly. Our findings, which show a positive association between distance to a referral hospital and mortality, illustrate the inequalities of healthcare access. Hence, the pandemic has illuminated an acute problem in Indonesia's healthcare system, which favours cities and leaves rural areas behind.<sup>56–59</sup>

The number of area health workers has no significant association with the risk of death due to COVID-19. There are several plausible explanations for this finding. First, the limited number of health workers in most villages in Malang Regency is due to the fact that most health workers are concentrated in areas near the city centre. Second, the finding may reflect most health workers' lack of skills and experience in handling COVID-19 patients as they received no training in COVID-19 treatment at the beginning of the outbreak. Most health workers are nurses and midwives whose main roles are in COVID-19 health promotion and not COVID-19 treatment. This lack of healthcare capacity is found not only in Malang Regency but also in many regions across the country, demonstrating the acute issue of unequal access to healthcare between urban and rural areas documented in various

studies. The insignificant relationship between village poverty and COVID-19 infection and mortality further explains the lack of healthcare capacity in managing the outbreak. Although wealthier areas may have larger numbers of better-quality healthcare providers, they are not necessarily able to successfully manage the pandemic. As a result, we did not find the risk of infection and death across poor and rich communities to be significantly different.

The negative association of community-based healthcare with COVID-19 infection and COVID-19 mortality may indicate the benefits of community-based healthcare interventions for COVID-19 prevention in rural areas, which often have limited access to various resources such as information related to COVID-19 prevention. At the district level, community-based healthcare is vital in supporting district governments in increasing COVID-19 awareness among villagers. The district government empowers health cadres at *Posbindu* and *Posyandu/Posyandu Lansia* as community COVID-19 task force teams responsible for monitoring individuals with suspected cases and disseminating COVID-19 early mitigation information. Previous studies have also demonstrated the benefits of such community activities to promote community resilience and to provide basic healthcare services in resource-poor settings.<sup>56 60</sup>

Another village characteristic that we hypothesised to be associated with COVID-19 infection is the number of indigenous sociocultural activities such as traditional wedding ceremonies (*mantenan*), traditional circumcision ceremonies (*khitan*), traditional birth celebrations (*tasyakuran melahirkan*), religious meetings (*pengajian*) and other sociocultural activities at which individuals within the community and between communities often gather.<sup>60</sup> The result of our unadjusted OR logistic regression indicates a positive and significant association with COVID-19 infection. However, null findings were shown within the adjusted model. These null findings may indicate that most of the indigenous sociocultural activities took place in villages in rural areas, where infection rates were still low in the early phase of the pandemic. However, given that the local authorities are struggling to control such traditional gatherings within communities, these sociocultural events may cause further COVID-19 clusters in the future.

Taken together, the findings of this rapid assessment offer two important policy implications that can aid in



**Table 3** Unadjusted and adjusted multilevel logistic regressions for mortality among patients with COVID-19 (N<sub>individual</sub>=551, N<sub>village</sub>=390)

Variables	Unadjusted OR	95% CI	P value	Adjusted OR	95% CI	P value
Individual determinants						
Age, years, reference: 17 years and younger						
18–44	0.51	0.10 to 2.58	0.420	10.52	3.29 to 33.59	0.000
45–60	2.62	0.59 to 11.52	0.201	186.00	49.32 to 701.39	0.000
61 years and older	5.32	1.17 to 24.10	0.030	364.22	88.57 to 1497.70	0.000
Male	1.45	0.84 to 2.49	0.176	2.93	1.49 to 5.75	0.002
Job type, reference: health workers						
Professional worker	0.97	0.07 to 12.05	0.985	0.01	0.00 to 0.19	0.003
Labourer	0.01	0.00 to 0.13	0.000	0.00	0.00 to 0.03	0.000
Trader	0.37	0.06 to 2.12	0.270	1.00	omitted	
Farmer	0.24	0.08 to 0.66	0.006	0.20	0.02 to 2.51	0.210
Retired	5.02	2.11 to 11.92	0.000	3.41	0.32 to 0.30	0.384
Had contact with confirmed COVID-19 cases	0.10	0.03 to 0.35	0.000	0.62	0.13 to 2.98	0.548
Had contact with suspected COVID-19 cases	0.22	0.07 to 0.74	0.014	0.64	0.10 to 3.90	0.627
Presence of comorbidities						
Diabetes	2.91	1.63 to 5.18	0.000	1.10	0.43 to 4.37	0.211
Heart diseases	2.68	0.52 to 13.59	0.233	1.75	0.51 to 5.98	0.375
Hypertension	2.22	1.21 to 4.08	0.010	17.01	5.34 to 54.20	0.000
Chronic obstructive pulmonary disease	24.81	2.53 to 242.40	0.006	2.12	0.47 to 9.66	0.330
Inpatient	18.03	6.38 to 50.95	0.000	30.48	13.68 to 67.91	0.000
intensive care unit	8.28	1.51 to 45.12	0.015	12.03	2.73 to 53.20	0.001
Medical doctor diagnosis before RT-PCR						
Pneumonia	13.07	5.99 to 28.53	0.000	4.75	2.33 to 9.65	0.000
Acute respiratory distress syndrome	11.16	2.43 to 51.13	0.002	5.99	1.23 to 29.17	0.027
Respiratory failure	3.05	0.78 to 11.84	0.106	2.12	0.81 to 5.54	0.127
Village determinants						
Number of community-based health interventions	0.99	0.99 to 1.00	0.252	0.98	0.97 to 1.00	0.008
Number of indigenous sociocultural activities	1.00	0.96 to 1.04	0.833	0.96	0.90 to 1.03	0.251
Village poverty status	0.59	0.28 to 1.22	0.162	0.97	0.00 to 312.57	0.306
Distance to COVID-19 epicentre city	0.99	0.96 to 1.02	0.660	0.99	0.92 to 0.98	0.513
Number of health workers	0.99	0.97 to 1.01	0.507	0.70	0.95 to 1.02	0.909
Distance to COVID-19 referral hospital	1.01	0.95 to 1.07	0.715	1.45	1.02 to 1.51	0.031
ICC				2.48e-34	7.85e-18	
Likelihood				-44.31		

RT-PCR, reverse transcription PCR.

preparing for COVID-19 outbreaks in rural Indonesia. First, with the lack of healthcare capacity to handle the pandemic in most rural areas, the government should prioritise the implementation of strategies to control the pandemic while improving essential facilities for

COVID-19 treatment in rural areas. For example, a system should soon be developed to monitor villagers' mobility (ie, how villagers are travelling and where they are going) and learn how rural communities are affected by the

movement of people who were in cities and have now returned to the countryside.

Our findings show that community-based health-care interventions may be used as an effective local institution to mitigate COVID-19 infection in rural settings, which often face limited basic health services and knowledge about COVID-19 infection. Such institutions may be effective in facilitating the dissemination of information in rural communities to help spread public health messages related to COVID-19.<sup>20</sup> A policy restricting human mobility should likewise be implemented to control the spread of the disease to rural areas. A realistic travel restriction would accommodate villagers who must travel to work in cities while providing them with regular COVID-19 tests to monitor virus spread.

As many government offices become COVID-19 clusters, the authorities should strengthen the implementation of COVID-19 health protocols in government offices by providing protective COVID-19 equipment. The authorities should also implement regular COVID-19 monitoring for civil servants, especially those who live in rural villages and those who are highly mobile. Moreover, public health mitigation strategies should strengthen physical and social distancing policies, especially for middle-aged men and older men as well as groups with generally high mobility, as most of their members work in informal sectors.<sup>10 11</sup>

Second, as the pandemic now threatens rural areas, providing COVID-19 emergency services for rural areas is vital for reducing mortality. Providing COVID-19 emergency transportation is crucial as patients with COVID-19 from rural villages tend to arrive at referral hospitals only when their condition has become critical. The authorities should also prepare to build emergency COVID-19 hospitals in rural areas rather than in urban areas when the number of patients with COVID-19 from rural areas has increased. COVID-19 mitigation strategies should also ensure the provision of essential medications, especially for men aged 45 years and older who have cardiometabolic conditions, specifically hypertension.<sup>7 8 12 14</sup> This is particularly important because the lack of essential medicine is a frequent issue in rural public health facilities in Indonesia. By prioritising the strengthening of the healthcare system in rural areas during the pandemic, the government may also be able to reduce inequality in healthcare services following the outbreak.

The empirical results reported here entail consideration of several limitations, of which this study has at least three. First, this is a rapid healthcare assessment which is based on 4 months of contact tracking data. The results may change as COVID-19 infections in the district increase. The contact tracing data used were based neither on random sampling nor on mass testing data; rather, they were selected based on three criteria of COVID-19 tracing. Thus, the data may be subject to selection bias (eg, the slightly lower proportion of female respondents), capturing Malang's working population

rather than representing the overall demographic characteristics of the district. However, the lower proportion of women may also relate to the abovementioned inequality in the provision of COVID-19 tests. Hence, we suggest that future research investigate the contribution of social norms and gender roles in order to identify how gender may influence risk of infection and access to care.

Second, we are unable to include certain main socio-economic determinants such as income and education as the data are unavailable or not yet integrated with citizen registration data. Therefore, future studies may examine whether income distribution and education level are associated with COVID-19 infections and deaths.

Third, some of the variables in this study were based on retrospective data, especially regarding respondents' histories of heart disease and diabetes. These data were thus subject to recall bias. Future studies may use medical record data collected from primary healthcare centres or hospitals to address the issue of recall bias.

**Twitter** Sujarwoto Sujarwoto @sujarwoto20

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**Contributors** SS: conceptualisation, data curation, formal analysis, methodology, supervision, validation, visualisation, writing the original draft, writing the review and editing, and the guarantor of this study. AM: conceptualisation, formal analysis, methodology, supervision, validation, writing the review and editing.

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**Patient consent for publication** Not applicable.

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**Data availability statement** Data are available in a public, open access repository. The data that support the findings of this study are available in the Zenodo repository: <https://zenodo.org/record/4408744#X-75ntgzPY> with the following digital object identifier: <http://doi.org/10.5281/zenodo.4408744>.

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#### ORCID iD

Sujarwoto Sujarwoto <http://orcid.org/0000-0003-4197-4592>

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