

# Hygiene and Sanitation Challenge for COVID-19 Prevention in Indonesia

Sang Gede Purnama<sup>1\*</sup>, Dewi Susanna<sup>2</sup>

<sup>1</sup>Doctoral Program in Public Health, Faculty of Public Health, Universitas Indonesia, Indonesia

<sup>2</sup>Department of Environmental Health, Faculty of Public Health, Universitas Indonesia, Indonesia

## Abstract

The case of COVID-19 in Indonesia continues to increase, transmitted directly and indirectly. Hygiene and sanitation approaches are needed for prevention. The purpose of this review is to review how the transmission COVID-19, the challenges of Indonesia, and the policy of COVID-19 prevention with hygiene and sanitation approaches. The results show Indonesia's challenges namely urban area density, air pollution, and smokers, low hand washing habits, low access to clean water and drinking water, open defecation behavior, limited personal protective equipment. COVID-19 control policy with the hygiene sanitation approach is carried out with 4 factors namely personal protect equipment, health education, personal hygiene, and sanitation.

**Keywords:** COVID-19, hygiene, sanitation, Indonesia

## Introduction

Coronavirus infectious diseases 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS COV-2) that initially occurred in Wuhan, China have now spread to many countries.<sup>1,2</sup> On March 11, 2020 World Health Organization (WHO) has established COVID-19 as a global pandemic.<sup>3,4</sup> The COVID-19 incident has spread to 213 countries including Indonesia. As of April 20, 2020, the total number of COVID-19 cases was 2,480,503 people with 170,397 deaths.<sup>5</sup>

Indonesia which has 34 provinces with a population of 267 million in 2019 Chinese tourists visited 1.61 million visits (13.14%).<sup>6</sup> Based on reports from the Ministry of Health and National Disaster Management Agency as of April 20, 2020, it was reported that COVID-19 reached 6,760 people, 590 deaths, and 747 people recovered.<sup>7</sup> Transmission that originally occurred to foreign citizens has now become a local transmission between people.<sup>8</sup> This incident is spreading quickly and the cases will continue to grow. Indonesia is at risk of COVID-19 transmission.

The COVID-19 transmission is reported to be directly and indirectly, directly through droplets when coughing.<sup>9</sup> Transmission occurs from person to person, especially in those who do not use personal protective equipment

(PPE) and contact with infected people.<sup>10-12</sup> Therefore WHO recommends doing physical distancing by keeping a distance and avoiding crowds and using masks.<sup>13</sup> Indirectly, by touching the surface of objects that have a virus and then touching the mouth, nose, and eyes before washing hands. SARS COV-2 was even found in eye fluid, this can be a source of infection.<sup>14</sup> Therefore it is advisable to wash hands with soap and disinfecting the surface of objects that are often used.<sup>15</sup> Handwashing with soap in Indonesia is very low, so there is a risk of transmission through hygiene.<sup>16</sup>

There was evidence SARS COV-2 is detected in feces and urine.<sup>17</sup> This was also confirmed by the liquid waste in sewerage in the Netherlands, the United States, and Sweden.<sup>18</sup> This condition is an early warning for Indonesia which has a greater challenge, namely open defecation behavior, which is still high, even the second largest in the world.<sup>19</sup> Based on the United Nations Children's Fund (UNICEF) data, it is stated that there are around 25 million people who still defecate in Indonesia.<sup>20</sup>

Stool contamination of clean water sources and community drinking water is very vulnerable to contracting COVID-19. In Indonesia, access to clean water and drinking water is still lacking. Based on national socio-

**Correspondence\***: Sang Gede Purnama, Doctoral Program in Public Health, Faculty of Public Health, Universitas Indonesia, Lingkar Kampus Raya Universitas Indonesia Street, Depok, West Java, Indonesia, E-mail: sangpurnama@unud.ac.id, Phone: +62-877-3917-6777

Received : May 28, 2020

Accepted : May 29, 2020

Published : July 30, 2020

economic survey data from Statistics Indonesia (*Badan Pusat Statistik/BPS*), only 72.04% of households have access to safe drinking water. The data indicated that there are around 80 million people who still do not have access to adequate drinking water.<sup>21</sup> Therefore, the existence of the COVID-19 pandemic makes people very vulnerable to be infected by the virus through contaminated drinking water.

The low personal hygiene and poor sanitation indicators in Indonesia are a challenge in controlling COVID-19 in Indonesia. Hygiene and sanitation factors need to get the attention of policymakers in controlling COVID-19. For this reason, the purpose of this article is to describe the mode of transmission, challenges, and policies related to controlling COVID-19 with the hygiene and sanitation approach in Indonesia.

**Mode of Transmission COVID-19**

Mode of transmission in COVID-19 with a journal review related to transmission and hygiene and sanitation factors that occur. Figure 1 explains how COVID-19 transmission is direct and indirect, and the potential for contamination of water sources. COVID-19 is transmitted directly through droplets when infected people cough and transmit it to others.<sup>22,23</sup> Several studies have shown, transmission from person to person through droplet splashing when people cough and sneeze within a distance of 1 meter or contact with an infected person without using PPE.<sup>24-27</sup> Therefore, contact tracers are needed in people who have been in contact with covid patients before. This requires a policy of using masks and keeping a distance from others.

Research shows SARS-CoV-2 is more stable in plastics and stainless steel than copper and cardboard, and viruses are detected up to 72 hours after application to

this surface.<sup>28</sup> This causes indirect transmission because the persistence virus is on the surface of the object to infect someone because when touch their eyes, nose and mouth.<sup>29-31</sup> SARS COV-2 is also found in eye fluid.<sup>14</sup> However, the use of disinfectants such as 71% ethanol, 0.5% hydrogen peroxide or 0.1% sodium hypochlorite can eliminate SARS COV-2 that contaminates the surface of the object.<sup>9</sup>

There is evidence that sputum, feces, and urine contain SARS COV-2.<sup>17,32</sup> Although until now there has been no evidence of transmission from fecal-oral this can be an early warning. Researchers found in the Netherlands, the United States, and Sweden that fecal waste discharged into sewerage was proven to be contaminated with SARS COV-2.<sup>18,33</sup> This needs serious attention, especially in Indonesia. Open defecation behaviour is still high. This can pollute the surface water supply. Furthermore, it can pollute community drinking water because access to our clean water is still low. This incident requires a special policy for the provision of healthy latrines and access to clean water. Medical waste treatment systems also need attention, especially solid and liquid waste so as not to pollute the waters used by the community for access to clean water.

**The Challenges of Hygiene and Sanitation at COVID-19 in Indonesia**

**Urban area density**

Indonesia which has a population of 268 million, most of the population lives in urban areas.<sup>21</sup> High inter-island population mobility, if there is a case of COVID-19 without symptoms but carrier,<sup>34</sup> then it can spread quickly. Especially in public transportation modes such as planes,<sup>35</sup> trains, markets, religious events, and weddings. Activity in the crowd can transmit COVID-19

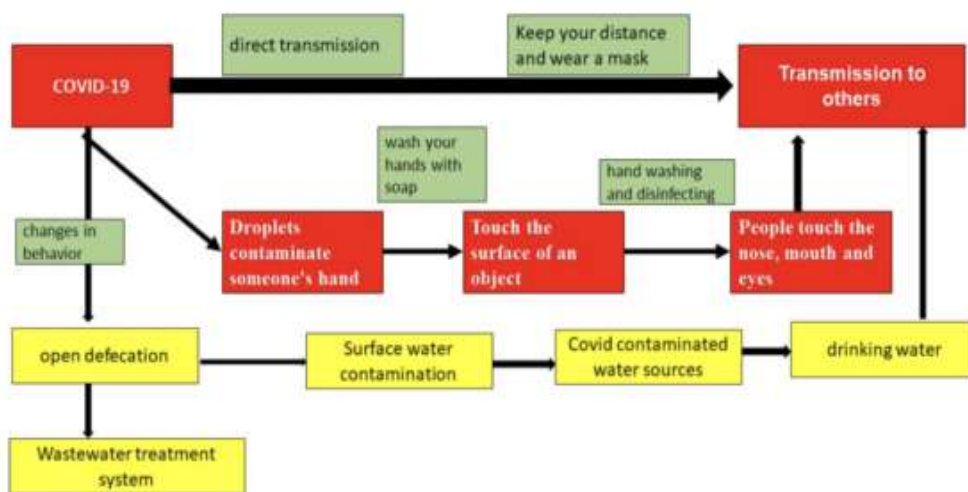


Figure 1. COVID-19 Transmission Patterns Related to Hygiene and Sanitation

quickly because droplets can spread and infect others. For this reason, social distancing is needed to reduce crowds, close schools, workplaces, terminals.<sup>36,37</sup>

The national socioeconomic survey reports that Indonesia has a population living in urban areas (52.9%) and living in homes with a floor area of fewer than 8 m<sup>2</sup> per capita (14.8%) and the population traveling last year (28.2%).<sup>38</sup> Living in a crowded house and a large number of residents and lack of air ventilation can interfere with health, especially airborne diseases.<sup>39</sup> The use of proper ventilation can help prevent airborne diseases that generally occur in homes in urban areas.<sup>40</sup> Increasing air ventilation is effective to reduce the risk of long-range airborne transmission and help prevent droplet-borne.<sup>41</sup>

### **Air pollution and smokers**

Air pollution in big cities in Indonesia is very high, making Indonesia 20 polluted countries in the world.<sup>42</sup> High air pollution can be a driving factor in the occurrence of respiratory disturbances.<sup>43-45</sup> High levels of air pollution can cause cardiovascular disease and respiratory disease.<sup>46</sup> According to WHO around 7.1 million people died due to the effects of air pollution and around 94% live in low and middle-income countries.<sup>47</sup>

The BPJS reports in Indonesia that the incidence of pneumonia is 1.3 per 1,000 population. Also, Indonesia ranks third in the world of tuberculosis with an estimated case of 845,000 people. The prevalence of acute respiratory infections in Indonesia reaches 9.3%.<sup>48</sup> This indicates that Indonesia already has a high respiratory disease burden. The symptoms of COVID-19, which is also pneumonia, will increase the number of respiratory diseases in Indonesia.

The Southeast Asia Tobacco Control Alliance (SEAT-CA) report mentions Indonesia as the country with the most smokers in Asia with 65.19 million people. They buy cigarettes installs, kiosks, minimarkets, and supermarkets.<sup>49</sup> The number of cases of tobacco-related diseases is 962,403 people. Chronic obstructive pulmonary disease is the most common type of tobacco-related disease, then severe low birth weight babies, coronary heart disease, stroke and lung tumors, bronchus, and trachea.<sup>50</sup> The WHO states smokers are at a higher risk of being infected with COVID-19, firstly because the fingers used for smoking directly touch the lips. Second, smokers may already have lung disease or not optimal lung capacity.<sup>51-53</sup>

### **Low handwashing habits**

The hand as a medium of transmission of COVID-19, touches the surface of objects contaminated with SARS COV-2 then touches the nose, mouth, and eyes.<sup>9,14</sup> The WHO recommends washing hands with soap and through running water to prevent COVID-19 because

washing hands not only prevents COVID-19 but also other diseases such as diarrhea and pneumonia.<sup>54</sup> Wash hands with soap strategies to save costs to reduce the burden of global disease.<sup>55</sup>

Basic Health Research data mentioned that 50.2% of improper hand washing.<sup>16</sup> The behavior of cleaning hands with soap and running water has been socialized through electronic media and print media. The School Health Unit program also promotes handwashing with soap but is still not optimal. Studies in Indonesia found that handwashing behavior is influenced by the presence and distance of handwashing facilities, interpersonal influence, the desire to smell good, washing hands when feeling dirty.<sup>55</sup> This behavior is closely related to COVID-19's control efforts.

### **Low access to clean water and drinking water**

Data from the central statistics agency states that access to safe water in Indonesia reaches 72.55%, which is still below the Sustainable Development Goals (SDGs) target of 100%.<sup>21</sup> As many as 33.4 million people still lack access to clean water. People who are difficult to get access to clean water will use water from polluted sources so that it can endanger their health. Polluted water sources are at risk of causing various types of digestive and skin disorders.<sup>56</sup>

The results of the national socio-economic survey from BPS show that households with access to decent drinking water in Indonesia in 2012 amounted to 65.05% of households. In 2014 it became 68.11% then increased in 2017 to 72.04%. This means that 80 million people still do not have access to adequate drinking water.<sup>21</sup> Utilization and management of drinking water that is not according to the standard also risk causing diarrhea, dysentery, cholera, and skin diseases. Especially concerning COVID-19, potential water sources are contaminated if drinking water is not treated properly.

Data from the Directorate General of Pollution Control and Environmental Damage stated that the quality of the river began to decline, by 23.5% with moderately polluted status and 55.88% with severe pollution.<sup>57</sup> This river pollution is caused by the disposal of household waste, industrial waste, and also from the residents' toilet. The heavy river pollution is not suitable for the community to use because it contains heavy metals and does not meet microbiological standards. The use of river water for bathing or drinking water is very dangerous. COVID-19 could have polluted the river from feces and stools that are directly discharged into the river.<sup>57</sup>

### **Open defecation**

The WHO/UNICEF data states that Indonesia is the second-largest country in the world where people still defecate openly.<sup>19</sup> Based on UNICEF data in 2015, there

are 32 million people who still defecate openly. Then in 2018, there will be 25 million people. Around 150,000 Indonesian children die each year from diarrhea and other diseases caused by poor sanitation.<sup>20</sup> Open defecation, such as in rivers, fields, forests, will pollute the soil and water. Related to COVID-19 discarding feces carelessly can contain SARS COV-2,<sup>58</sup> which causes contamination in the environment and surface water.

Based on World Bank data, it is known that of the 60% of the urban population that is still open defecation as many as 14% and 62% have a septic tank but do not have a sewage treatment system. Total losses due to poor sanitation reached USD 6.3 billion.<sup>59,60</sup> Waste disposal directly into rivers, in the soil and waterways without proper waste treatment, can pollute the environment. Groundwater and surface water can be polluted by bacteria and viruses.

**A limited supply of personal protective equipment (PPE)**

Since the COVID-19 pandemic, the need for personal protective equipment such as face masks is very high. This makes it difficult for the public and health workers to get face masks. Limited personal protective equipment such as face masks for the general public and special equipment for health workers such as N95 masks, gloves, eye protection, dresses need to be addressed immediately.

The limitations of PPE can endanger health workers in handling COVID-19 patients. Efforts to produce local PPE are needed to meet market needs. WHO recommends that the general public use cloth masks and health workers use standard clothing for handling patients with COVID-19.<sup>61,62</sup>

**COVID-19 Prevention Policy with Hygiene and Sanitation Approach**

COVID-19 transmission that is known directly through droplets from sufferers to others needs to be prevented by using PPE.<sup>10</sup> Indirect transmission through means and touch to the mouth, eyes, and nose requires personal hygiene. There is potential for environmental pollution from feces that can pollute clean water and community drinking water. Need to get attention to environmental sanitation. Therefore, we need policies that support prevention with aspects of environmental hygiene and sanitation, namely personal protect equipment, health education, personal hygiene, and sanitation which is described in Table 1. This policy is formulated in Figure 2.

**Use of standard personal protective equipment**

The first step to reduce COVID-19 contamination through direct transmission is the use of masks. World Health Organization recommends that it is required to

Table 1. Hygiene and Sanitation Factors for COVID-19

Personal Protect Equipment (PPE)	Health Education	Personal Hygiene	Sanitation
<ul style="list-style-type: none"> <li>• Use a face mask for everyone</li> <li>• Provision of standard PPE to medical staff</li> <li>• Physical distancing</li> </ul>	<ul style="list-style-type: none"> <li>• Formation of a task force team</li> <li>• Education about hygiene and sanitation in the family, school, community and workplace environment</li> <li>• Risk communication on electronic media, print media and social media</li> </ul>	<ul style="list-style-type: none"> <li>• Washing hands with soap and water</li> <li>• Do not touch the face before washing hands</li> <li>• Come home, take a shower before touching objects</li> <li>• Stop open defecation</li> </ul>	<ul style="list-style-type: none"> <li>• Provision of handwashing facilities in public facilities</li> <li>• Routinely disinfecting objects that are frequently touched</li> <li>• Provision of clean and safe water facilities</li> <li>• Wastewater management</li> </ul>



Figure 2. Prevent COVID-19 Use Hygiene and Sanitation Approach

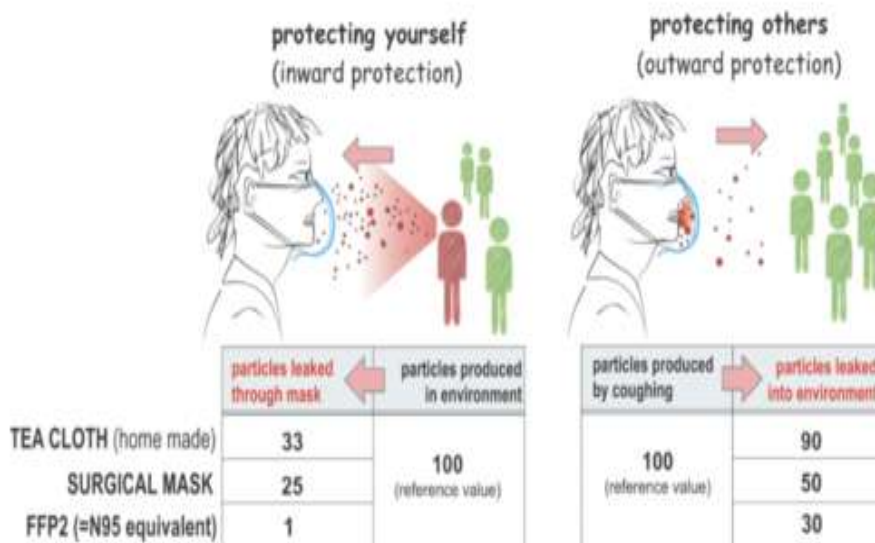


Figure 3. The Use of Masks to Protect Us and Others from COVID-19 Exposure<sup>64</sup>

use masks for everyone.<sup>24</sup> This helps to reduce the risk of exposure of COVID-19 sufferers to others and also the risk of transmitting COVID-19 to others. So in principle, we protect others and others protect us (see in Figure 3).

Availability of standard personal protective equipment (PPE) for medical staff treating patients with COVID-19.<sup>15</sup> The need for PPE medical standards has increased in the world since the pandemic occurred. Health workers are vulnerable to COVID-19 contamination when treating COVID-19 patients. High intensity with COVID-19 patients requires using PPE such as N-95 masks, glasses, hazard material clothing, shoe protectors as well as medical waste disposal containers and their sterile treatment.<sup>26</sup> Without the proper PPE, transmission from patients to health care workers is vulnerable. There is also the possibility of patient-to-patient transmission in hospitals.<sup>64</sup>

### Physical distancing

World Health Organization recommends keeping a safe distance of more than 1 meter from other people (physical distancing). It aims to reduce direct contact with other people who are symptomatic in COVID-19 and those who are asymptomatic but have the potential to transmit.<sup>13</sup> This policy is effective in reducing the potential for virus transmission.<sup>37</sup> This action was followed by a policy of reducing gatherings, closing schools, workplaces, markets, public transportation, religious ceremonies, and marriages.<sup>38</sup> This policy also encourages people to stay at home, work at home, study at home, worship at home.

### Health education program with risk communication

Since March 17, 2020, Indonesia has formed a task force for handling COVID-19 which is coordinated by the National Disaster Management Agency (BNPB). The task force is expected to be able to accelerate efforts to handle COVID-19 in various areas ranging from preparation in handling, preventing, detecting, and responding. Structural task forces exist from the central to the village level.<sup>65</sup>

Officers must provide education about hygiene and sanitation in the family, school, community, and workplace environment related to COVID-19.<sup>66</sup> The role of community leaders, teachers, parents is needed in collaboration to provide education in their respective environments. A good understanding of transmission, control, and preventive actions can help the community in dealing with the COVID-19 pandemic.

Risk communication on electronic media, print media, and social media to provide information to the public quickly and accurately through trusted sources. This is to avoid hoax information and create confusion in the community. Incorrect and insistent information can cause anxiety and excessive fear in the community. For this reason, a centralized information and education system are needed in each region and confirmation of hoax news.

### The personal hygiene improvement program

The discovery of SARS COV-2 contamination that causes COVID-19 in feces,<sup>67</sup> and liquid waste requires efforts to anticipate the occurrence of contamination in community sewage.<sup>18,33,68</sup> Habits of people who defecate carelessly in Indonesia are still high. This behavior is

very dangerous because it can contaminate water sources so that the potential for transmission occurs through drinking water residents. This is an early warning to take precautionary measures by stopping open defecation.

Sanitation improvement programs in Indonesia so far have been carried out through Community-based Total Sanitation & Hygiene (CLTS) Strategy with 5 main pillars namely Open Defecation Free communities, Handwashing with soap at critical moments, Household water treatment and safe storage of water and food, Solid waste management and Liquid waste management. CLTS increases toilet construction with community participation,<sup>69,70</sup> so that the CLTS program is more optimal, it requires high-level political commitment, integration of sanitation programs into health programs, improvement of community hygiene and coordination multi-sector.<sup>71</sup> Multi-sector cooperation is needed for optimal program implementation.

The handwashing with soap program is carried out simultaneously to break the chain of transmission of COVID-19. Hands indirectly as a medium of transmission of COVID-19 through touch on the eyes, nose, and mouth. Indonesian people's handwashing habits are still very low. There are 50.2% of people who do not wash their hands properly.<sup>16</sup> To prevent transmission of COVID-19, it is necessary to move the handwashing program using soap before touching the mouth, nose, and eyes.

### Provision of environmental sanitation facilities

Provision of handwashing facilities in public facilities. To support the habits of the community who wash their hands, hand washing facilities are needed in public facilities, namely markets, terminals, places of worship, schools, and others. This handwashing facility is useful in supporting efforts to prevent COVID-19 transmission in the community. The availability of handwashing facilities helps the community get used to washing hands with soap in public places.

Disinfecting public facilities and items that are often used such as dining tables, cellphones, cabinets, algae doors, elevator buttons, and others.<sup>12</sup> Disinfectant action can kill the SARS COV-2 virus that is on the surface of objects, which are around us such as the surface of wood, plastic, metal, aluminum, copper, and cardboard. The virus can persist for up to 72 hours on these objects. Routine item sterilization needs to be done for objects that are frequently touched.<sup>9</sup>

Provision of clean water and proper drinking water facilities for the community. Access to clean water and proper drinking water is still low in Indonesia. People who do not get access to properly clean water, use water sources that are polluted and at risk of being contaminated by COVID-19. Clean water sources should be provided

through processing and piping facilities so that the quality is guaranteed. COVID-19 can pollute community water sources through contaminated faeces.<sup>17</sup>

Liquid waste treatment and waste management program. SARS COV-2 was found to be found in sewerage.<sup>33</sup> Most households in Indonesia do not have a communal waste treatment system, most only have latrines and septic tanks without further processing. Waste treatment systems need to be carried out before being discharged into the environment. For medical waste produced including hazardous and toxic materials that need special treatment in handling so as not to pollute the environment and contaminate humans. The solid waste generated from infectious hospitals must not be disposed of directly into the landfill, but can use an incinerator or a third party for disposal.

### Conclusion

COVID-19 transmission can occur directly through droplets to other people or indirectly through touching the surface of an infective object. Hygiene prevention such as using masks and washing hands is needed. This article also discusses Indonesia's challenges in controlling covid is urban area density, air pollution and smoking, low hand washing habit, low access to clean water and drinking water, open defecation. hygiene and sanitation approach namely through personal protect equipment, health education, personal hygiene and sanitation.

### Abbreviations

COVID-19: Coronavirus infectious diseases 2019; SARS COV-2: severe acute respiratory syndrome coronavirus 2; WHO: World Health Organization; PPE: Personal Protective Equipment; UNICEF: United Nations Children's Fund; BPS: Statistics Indonesia (*Badan Pusat Statistik*); BPS: ; SEATCA: Southeast Asia Tobacco Control Alliance; SDGs: Sustainable Development Goals; CLTS: Community-based Total Sanitation & Hygiene.

### Ethics Approval and Consent to Participate

Not Applicable

### Competing Interest

No potential competing interest was reported by the authors.

### Availability of Data and Materials

All data generated or analyzed during this study are included in this published article.

### Authors' Contribution

Sang Gede Purnama: Development and design of the models, creation and presentation of the published work, specifically writing the initial draft (including substantive translation); Dewi Susanna: Analyze the review, commentary and revision – including pre- or post-publication stages.

### Acknowledgment

The authors are grateful to Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal) for providing the editing English services to this manuscript.

### References

1. Oon-Tek Ng, Kalisvar Marimuthu, Po-Ying Chia, Vanessa Koh P, Calvin JC, Liang DW, et al. SARS-CoV-2 infection among travelers returning from Wuhan, China. *The New England Journal of Medicine*. 2020; 382: 1476-8.
2. Zhang D, Wang W, Xingwang, Yang B et al. A novel coronavirus from patients with pneumonia in China, 2019. *The New England Journal of Medicine*. 2020; 382 (8): 727–35.
3. World Health Organization. WHO director - general's opening remarks at the media briefing on COVID-19 - 11 March 2020. Geneva; 2020.
4. Callaway BE, Cyranoski D, Mallapaty S, Stoye E, Tollefson J. Coronavirus by the numbers. *Nature*. 2020; 579 (7800): 482–3.
5. World Health Organization. Coronavirus disease (COVID-2019) situation reports. Geneva; 2020.
6. Badan Pusat Statistik. Jumlah kunjungan wisatawan mancanegara. Indonesia; 2019.
7. Badan Nasional Penanggulangan Bencana. Report COVID-19 in Indonesia. 2020.
8. Liu YC, Liao CH, Chang, Chou CC, Lin YR. A locally transmitted case of SARS-CoV-2 infection in Taiwan. *The New England Journal of Medicine*. 2020; 382 (11): 1070-2.
9. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *Journal of Hospital Infection*. 2020; 104 (5): 246–51.
10. Ghinai I, Mcpherson TD, Hunter JC, Kirking HL, Christiansen D, Joshi K, et al. Articles first known person-to-person transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in the USA. *Lancet*. 2020; 395: 1137–44.
11. Qun Li, Xuhua Guan, Peng Wu, Xiaoye Wang, Lei Zhou, Yeqing Tong, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *The New England Journal of Medicine*. 2020; 382: 1199–207.
12. Deng S, Peng H. Characteristics of and public health responses to the coronavirus disease 2019 outbreak in China. *Journal of Clinical Medicine*. 2020; 9 (2): 575.
13. World Health Organization. COVID-19. Geneva; 2020.
14. Colavita F, Lapa D, Carletti F, Lalle E, Bordini L, Marsella P, et al. SARS-CoV-2 isolation from ocular secretions of a patient with COVID-19 in Italy with prolonged viral RNA detection. *Annals of Internal Medicine*. 2020; M20-1176.
15. Adhikari SP, Meng S, Wu Y, Mao Y, Ye R, Wang Q, et al. Epidemiology, causes, clinical manifestation and diagnosis, prevention and control of coronavirus disease ( COVID-19 ) during the early outbreak period: a scoping review. *Infectious Disease of Poverty*. 2020; 9 (29): 1–12.
16. Kementerian Kesehatan Republik Indonesia. Riset kesehatan dasar 2018. Jakarta; 2018.
17. Chen C, Guiju G, Yanli Xu, Lin P, Qi W, Liming W et al. SARS-CoV-2-positive sputum and feces after conversion of pharyngeal samples in patients with COVID-19. *Annals of Internal Medicine*. 2020; 172 (12): 832-4.
18. Mallapaty S. How sewage could reveal true scale of coronavirus outbreak. *Nature*. 2020; 580 (7802): 176-7.
19. World Health Organization. Water sanitation hygiene; 2012.
20. Joint World Health Organization/United Nations Children's Fund Press Release. Progress on household drinking water, sanitation and hygiene 2000-2017: special focus on inequalities. New York; 2019.
21. Sub Direktorat Statistik Rumah Tangga. Indonesia - survei sosial ekonomi nasional 2017 maret (KOR). Jakarta: Badan Pusat Statistik; 2018: pp. 1–230.
22. Pan Zhai, Yanbing Ding, Xia Wu, Junke Long, Yanjun Zhong, Yimng Li. The epidemiology, diagnosis and treatment of COVID-19. *International Journal of Antimicrobial Agents*. 2020; 55 (5): 105955.
23. Chih-Cheng L, Tzu-Ping S, Wen-Chien K, Hung-Jen T, Po-Ren H. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and coronavirus disease-2019 (COVID-19): the epidemic and the challenges. *International Journal of Antimicrobial Agents*. 2020; 55 (3): 105924.
24. World Health Organization. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations; 2020.
25. Chan JFW, Yuan S, Kok KH, To KKW, Chu H, Yang J, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. 2020; 395 (10223): 514–23.
26. Ong SWX, Tan YK, Chia PY, Lee TH, Ng OT, Wong MSY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA*. 2020; 323 (16): 1610-2.
27. Wu Y, Chen C, Chan Y. The outbreak of COVID-19: an overview. *Journal of the Chinese Medical Association*. 2020; 83 (3): 217–20.
28. Doremalen Nv, Bushmaker T, Morris H, Holbrook M G, Gamble A, Williamson B N, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *The New England Journal of Medicine*. 2020; 382:1564-7.
29. Bai Y, Yao L, Wei T, Tian F, Jin D Y, Chen L, et al. Presumed asymptomatic carrier transmission of COVID 19. *The New England Journal of Medicine*. 2020; 323 (14): 1406-7.
30. Lirong Z, Feng R, Mingxing H, Lijun L, Huitao H, Zhongsi H, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *The New England Journal of Medicine*. 2020; 382: 1177-9.
31. Rothe C, Schunk M, Sothmann P, Bretzel G, Froeschl G, Wallrauch C, et al. Transmission of 2019-nCoV infection from an asymptomatic contact in Germany. *The New England Journal of Medicine*. 2020; 382: 970–1.
32. Jordan H. COVID-19: fecal-oral transmission?. *Nature Review Gastroenterology & Hepatology*. 2020; 17 (5): 259.
33. Lodder W, Husman AMdR. SARS-CoV-2 in wastewater: potential health risk, but also data source. *Lancet Gastroenterology Hepatology*. 2020; 5 (6): 533–4.
34. Chih-Cheng L, Yen Hung L, Cheng-Yi W, Ya-Hui W, Shun-Chung H, Muh-Yen Y, et al. Asymptomatic carrier state, acute respiratory dis-

- ease, and pneumonia due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2): facts and myths. *Journal of Microbiology, Immunology and Infection*. 2020; 53 (5): 404-12.
35. Wells CR, Sah P, Moghadas SM, Pandey A, Shoukat A, Wang Y, et al. Impact of international travel and border control measures on the global spread of the novel 2019 coronavirus outbreak. *PNAS - Proceedings of the National Academy of Sciences of the United States of America*. 2020; 117 (13): 7504-9.
  36. Lewnard JA, Lo NC. Scientific and ethical basis for social-distancing interventions against COVID-19. *The Lancet Infectious Diseases*. 2020; 20 (6): 631-3.
  37. Prem K, Liu Y, Russell TW, Kucharski AJ, Eggo RM, Davies N, et al. The effect of control strategies to reduce social mixing on outcomes of the COVID-19 epidemic in Wuhan, China: a modeling study. *The Lancet Public Health*. 2020; 5 (5): 261-70.
  38. Badan Pusat Statistik. *Survei Sosial Ekonomi Nasional*. Jakarta; 2017.
  39. Atkinson J, Chartier Y, Silva CLP, Jensen P, Yuguo L, and Seto WH. Natural ventilation for infection control in health-care settings - NCBI bookshelf. Geneva: World Health; 2009.
  40. Gao X, Wei J, Lei H, Xu P, Cowling BJ, Li Y. Building ventilation as an effective disease intervention strategy in a dense indoor contact network in an ideal city. *PLoS One*. 2016; 11 (9): e0162481.
  41. Qian H, Zheng X. Ventilation control for airborne transmission of human exhaled bio-aerosols in buildings. *Journal of Thoracic Disease*. 2018; 10 (Suppl 19): S2295-304.
  42. Greenstone M, Fan Q. Indonesia's worsening air quality and its impact on life expectancy. *Air Quality Life Index*; 2019.
  43. Conticini E, Frediani B, Caro D. Can atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy?. *Environmental Pollution*. June 2020; 261: 114465.
  44. Sun Z, Zhu D. Exposure to outdoor air pollution and its human-related health outcomes: an evidence gap map. *BMJ Open* 2019; 9: e031312.
  45. Sweileh WM, Al-Jabi SW, Zyoud SH, Sawalha AF. Outdoor air pollution and respiratory health: a bibliometric analysis of publications in peer-reviewed journals (1900 - 2017). *Multidisciplinary Respiratory Medicine*. 2018; 13: 15 (1-12).
  46. Ghorani-Azam A, Riahi-Zanjani B, Balali-Mood M. Effects of air pollution on human health and practical measures for prevention in Iran. *Journal of Research in Medical Sciences*. 2016; 21: 65.
  47. World Health Organization. Burden of disease from the joint effects of household and ambient air pollution for 2016: summary of results; 2018.
  48. Kementerian Kesehatan Republik Indonesia. *Diseases report*; 2018.
  49. Mark Drajem, Lorraine Woellert. Clove cigarettes may prompt U.S., Indonesia dispute. *Southeast Asia Tobacco Control Alliance*. 2018; pp. 1-144.
  50. Infodatin. *Situasi umum konsumsi tembakau di Indonesia*. Jakarta: Kementerian Kesehatan Republik Indonesia; 2019.
  51. World Health Organization. Tobacco free initiative: tobacco and waterpipe use increases the risk of suffering from COVID-19; 2020.
  52. Terzikhan N, Verhamme KMC, Hofman A, Stricker BH, Brusselle GG, Lahousse L. Prevalence and incidence of COPD in smokers and non-smokers: the Rotterdam study. *European Journal of Epidemiology*. 2016; 31 (8): 785-92.
  53. Vardavas C, Nikitara K. COVID-19 and smoking: a systematic review of the evidence. *Tobacco Induced Diseases*. 2020; 18: 20.
  54. World Health Organization. Improve hand hygiene practices widely to help prevent the transmission of the COVID-19; 2020.
  55. Hirai M, Graham JP, Mattson KD, Kelsey A, Mukherji S, Cronin AA. Exploring determinants of handwashing with soap in Indonesia: a quantitative analysis. *International Journal of Environmental Research and Public Health*. 2016; 13 (9): 868.
  56. Patunru AA. Access to safe drinking water and sanitation in Indonesia. *Asia & Pacific Policy Studies*. 2015; 2 (2): 234-44.
  57. Kementerian Lingkungan Hidup & Kehutanan Republik Indonesia. *Laporan Kinerja Kementerian Lingkungan Hidup dan Kehutanan Tahun 2017*; 2018.
  58. Tang A, Tong Z-d, Wang H-l, Dai Y-x, Li K-f, Liu J-n, et al. Detection of novel coronavirus by RT-PCR in stool specimen from asymptomatic child, China. *Emerging Infectious Disease*. 2020; 26 (6).
  59. World Bank Group. *Water supply and sanitation in Indonesia turning finance into service for the future*. Washington; 2015: pp. 1-88.
  60. World Bank. September 2015. World Bank: Washington; 2015.
  61. World Health Organization. Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19); 2020.
  62. Yi Y, Lagniton PNP, Ye S, Li E, Xu R. COVID-19: what has been learned and to be learned about the novel coronavirus disease. *International Journal of Biological Sciences*. 2020; 16 (10): 1753-66.
  63. Huang S. COVID-19: why we should all wear mask— there is new scientific rationale. *Medium*. 2020;
  64. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020; 323 (11): 1061-9.
  65. Gugus Tugas Percepatan Penanganan COVID-19. *Pedoman penanganan cepat medis dan kesehatan masyarakat COVID-19 di Indonesia*. Jakarta; Maret 2020: pp.1-38.
  66. Roy D, Tripathy S, Kar SK, Sharma N, Verma SK, Kaushal V. Study of knowledge, attitude, anxiety & perceived mental healthcare need in Indian population during COVID-19 pandemic. *Asian Journal of Psychiatry*. 2020; 51: 102083.
  67. Yuen KS, Ye ZW, Fung SY, Chan CP, Jin DY. SARS-CoV-2 and COVID-19: the most important research questions. *Cell & Bioscience*. 2020; 10 (40).
  68. Gormley M, Aspray TJ, Kelly DA. COVID-19: mitigating transmission via wastewater plumbing systems. *The Lancet Global Health*. 2020; 8 (5): e643.
  69. Cameron L, Olivia S, Shah M. Scaling up sanitation: evidence from an RCT in Indonesia. *Journal of Development Economics*. 2019; 138: 1-16.
  70. Venkataramanan V, Crocker J, Karon A, Bartram J. Community-led total sanitation: a mixed-methods systematic review of evidence and its quality. *Environmental Health Perspectives*. 2018; 126 (2): 026001.
  71. Zuin V, Delaire C, Peletz R, Cock-Esteb A, Khush R, Albert J. Policy diffusion in the rural sanitation sector: lessons from community-led total sanitation (CLTS). *World Development*. 2019; 124: 104643.