



Adjustment of *in vitro* Fertilization Clinic Management during COVID-19 Pandemic: A Study among Laboratory Staff in Indonesia

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Abstract

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BACKGROUND AND OBJECTIVES: The Ministry of Health as a national authority and several international organizations highly recommend that each *in vitro* fertilization (IVF) clinic conducts reviews for service regulations and makes adjustments for the patient's services according to the COVID-19 pandemic.

AIM: A survey of IVF clinic management in Indonesia during the COVID-19 pandemic needs to be carried out so that the results of the survey can be used as an evaluation material for the management to improve services safely.

METHODS: This cross-sectional survey was conducted among 49 IVF laboratory staff members of Indonesian Society of Human Embryologists from 42 IVF clinics in Indonesia. We administered an online questionnaire containing several questions related to the management of IVF clinic services during the COVID-19 pandemic based on a search of scientific literature.

RESULTS: Several services adjustments have been made by IVF clinic management in response to the COVID-19 pandemic to minimize transmission of the virus in the IVF clinic. The IVF clinic management revised the service regulations and the patient services procedure was also undergone several adjustments, to minimize the COVID-19 transmission.

CONCLUSIONS: Several IVF clinic managements adjustments were made by IVF clinic management in Indonesia as an early response to the COVID-19 pandemic. Clinic managements compile several adjustments to the service regulations during the COVID-19 pandemic as one of the readiness of IVF clinics in providing safe services for patients and staff.

Introduction

There was a pneumonia outbreak in December 2019, caused by severe acute respiratory syndrome coronavirus 2, namely, coronavirus disease 19 (COVID-19), firstly to be identified in Wuhan, China and spread to some countries and was declare as a pandemic [1], [2]. COVID-19 pandemic is still to be focus of attention in many countries until today, including Indonesia. There were 1,288,833 positive cases in Indonesia until February 22, 2021 [3]. With the increasing number of COVID-19 cases in Indonesia, several adjustments to health service activities need to be made, including *in vitro* fertilization (IVF) clinic services.

The Ministry of Health as a national authority, as well as several organizations such as the Centers for Disease Control and Prevention (CDC), American Society for Reproductive Medicine (ASRM), Society for Assisted Reproductive Technology (SART), and other sources highly recommends that each IVF laboratory/clinic conducting reviews for every service regulation and makes several adjustments for the patient's services according to ongoing COVID-19 pandemic conditions [4].

Several adjustments to IVF clinic services need to be made based on recommendations and the latest evidence regarding the COVID-19 pandemic. IVF clinic staff must increase vigilance and compliance in implementing health protocols to avoid transmission of COVID-19. It is possible that the source of COVID-19 contamination comes from patients or staff, so it is necessary to limit contact between staff and patients by consulting through telephone or video call. It is necessary to do patients' health status screening before receiving services to minimize the risk of transmission in the IVF clinic. Screening for health conditions is also mainly performed on patients who will undergo a sperm cryopreservation program [5], [6].

In addition, the processing of biological samples in the laboratory is carried out by increasing universal precautions [5]. A study shows the possibility of transmission of COVID-19 through semen, so it requires good sample handling while working in the laboratory. It is not certain about the transmission of COVID-19 through the follicular fluid. However, laboratory staff needs to be careful to avoid spills. Moreover, the laboratory staff must ensure that the follicular fluid container is properly closed after oocyte screening [7]. A survey of IVF clinics management in

Indonesia during COVID-19 pandemic needs to be carried out, so that the results of the survey can be used as an evaluation material for the management to improving the quality and safety in providing services in the IVF clinic.

Methods

Ethical consideration

Ethical clearance was obtained from the Medical and Health Research Ethics Committee Faculty of Medicine, Public Health, and Nursing Universitas Gadjah Mada-DR. Sardjito General Hospital. The protocol number of the clearance is KE/FK/0066/EC/2021 dated February 4, 2021. Participant data are collected anonymously. The study participants are given an informed consent containing an explanation regarding the survey and have the right to refuse at any time.

Study population and participants

Data from the Indonesian Society of Human Embryologists (ISHE) show that there were 42 IVF clinics in Indonesia by 2020, with 104 IVF laboratory staff have joined the ISHE [8]. We sent online survey questionnaires through WhatsApp to all ISHE members and gave each IVF clinic management full authority to represent their IVF laboratory staff involved as study participants by filling out the online survey questionnaires. A number of 49 complete questionnaires were received during the study period, that is, February 5–19, 2021.

Study design

This cross-sectional survey was conducted among 49 IVF laboratory staff members of ISHE from 42 IVF clinics in Indonesia. Due to the COVID-19 pandemic making face-to-face interviews with study participants impossible, we administered an online questionnaire using Google Form (Alphabet, Inc., Mountain View, California, United States). The survey questionnaire contains several questions related to the management of IVF clinic services during the COVID-19 pandemic based on the search of scientific literature [4], [5], [9], [10]. This survey received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Questionnaire design

The questionnaire consists of nine main components including demographic characteristics, IVF clinic services regulations, IVF laboratory staff

management, patient management, IVF clinic environment management, patient services and examination procedures, use of personal protective equipment (PPE), use of laboratory equipment, and laboratory disinfection.

Statistical analysis

Collected data are downloaded, transferred to Microsoft Excel (Microsoft Corp., Redmond, Washington, United States), and processed using the calculation of the percentage of each question on the nine questionnaire components.

Results

Demographic characteristics of *in vitro* fertilization clinic staff

A total of 49 IVF laboratory staff from 42 IVF clinics in Indonesia took part in this study. Based on Table 1, female participants were more than men ($n = 40, 81.4\%$) and 49% of all participants were in the

Table 1: Demographic characteristics of *in vitro* fertilization clinic staff ($n = 49$)

Characteristics	<i>n</i> (%)
Sex	
Female	40 (81.4)
Male	9 (18.6)
Age group	
25–30	12 (24.5)
31–40	24 (49)
41–50	7 (14.3)
>50	6 (12.2)
Competency	
Trainee	0
Junior embryologist	11 (22)
Senior embryologist	22 (45)
Supervisor	16 (33)
Educational background	
Diploma	3 (6.1)
Bachelor degree	26 (53.1)
Master degree/specialist	15 (30.6)
Doctoral degree	5 (10.2)
Experience (years)	
1–5	15 (30.6)
6–10	13 (26.5)
11–15	15 (30.6)
>15	6 (12.2)
IVF clinic location	
Sumatra	6 (12.3)
Java	38 (77.6)
Sulawesi	2 (4.1)
Kalimantan	2 (4.1)
Bali	1 (2)
Number of IVF cycle/year	
<10	1 (2)
10–50	11 (22)
51–100	16 (33)
>100	21 (43)
Number of sperm analysis/month	
<50	24 (49)
50–100	15 (30.6)
>100	10 (20.4)
Number of sperm preparation/month	
<50	2 (4.1)
50–100	32 (65.3)
>100	15 (30.6)
Number of gamete and embryo cryopreservation/year	
<10	6 (12)
10–50	21 (43)
51–100	7 (14)
>100	15 (31)

IVF: *in vitro* fertilization.

31–40 years age group. Most of the study participants were senior embryologists (45%) with the majority of educational background Bachelor's degrees (53.1%). The majority of participants came from the IVF clinics located at Java (77.6%) with 1–5 (30.6%) and 11–15 years of working experience (30.6%). Most of the participants had >100 IVF cycles/year (43%), 50–100 sperm analysis/month (30.6%), 50–100 sperm preparations/month (65.3%), and 10–50 gamete and embryo cryopreservation/year (43%).

As depicted in Figure 1a, 100% of study participants stated that there was IVF clinic services regulation made by IVF clinic managements during the COVID-19 pandemic and also the regulation for implementing health protocols for staff and visitors. A number of 95.9% of study participants stated that there was socialization of the regulation to the staff by the IVF clinic management, and 100% of all participants stated that they understood every regulation and procedure applied in the IVF clinic.

Management of in vitro fertilization clinic staff

The survey result on the management of IVF clinic staff in Indonesia during the COVID-19 pandemic is shown in Figure 1b. About 49% of participants stated that they were divided into mini teams while working in the laboratory by IVF clinic managements. A number of 71.4% of participants stated that the management of the IVF clinic applies a regulation to conduct health screening for staff before starting their work. The majority of participants stated the availability of officers

to measure the visitors' body temperature at the IVF clinic (98%). A number of 53.1% of participants stated that there was a risk mitigation training for IVF clinic staff. In addition, there were changes to the regular meeting mechanism implemented by management through online meetings (67.3%).

Management of in vitro fertilization clinic patients' services

Figure 1c shows the results of a survey of patient services management at IVF clinics. A number of 83.7% of participants stated that there was a specific officer who screen the patient's health through WhatsApp, Email, or telephone before getting services at the IVF clinic. A number of 57.1% of participants stated that there was a limitation on the number of patients by IVF clinic managements. There was a schedule for patient visits in most IVF clinics (83.7%).

Management of in vitro fertilization clinic environment setting

As depicted in Figure 1d, only 26.5% of participants stated that the IVF clinic where they work implemented the separation of entry and exit routes to the clinic area. Some of the participants stated that there are available adequate handwashing stations provided by the management (89.8%). Adequate hand sanitizer access for staff and visitors was available at all IVF clinics (100%). A number of 61.2% of participants stated that management provided a specific area for the supply of laboratory materials and equipment.

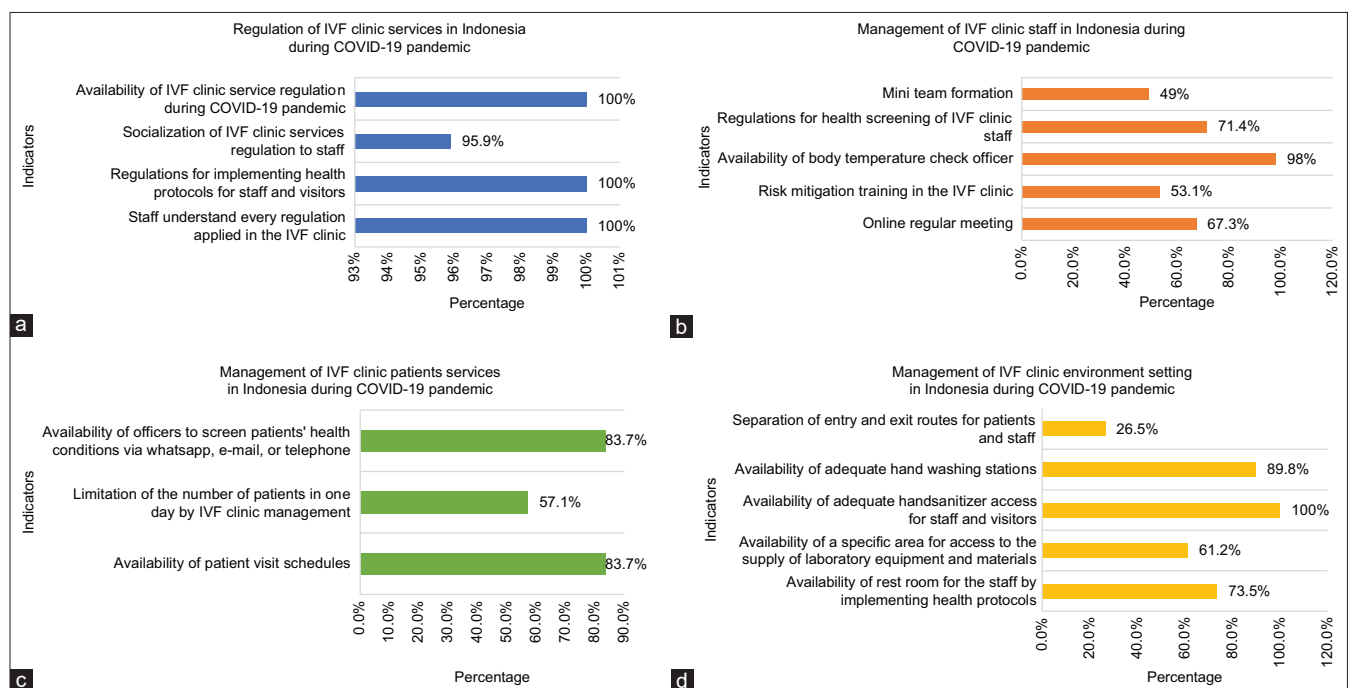


Figure 1: Management of IVF clinic in Indonesia during COVID-19 pandemic: (a) Availability of IVF clinic services regulation; (b) Management of IVF clinic staff; (c) Management of IVF clinic patients' services; (d) Management of IVF clinic environment setting

A number of 73.5% of participants stated that a restroom was provided for IVF clinic staff by implementing health protocols.

In vitro fertilization laboratory examination procedure

IVF laboratory examination procedure survey results are shown in Figure 2a. Of laboratory staff surveyed in this study, 34.7% stated that there was a reduction in their IVF clinic service hours. Around 55.1% of participants stated that consultations with patients were conducted online during the pandemic. To facilitate adequate air exchange in the laboratory room, 51% of participants said that they were extended the time lag between each laboratory examination. IVF clinic management restricts visitors except patients to prevent crowds on-site (87.8%). A number of 26.5% of participants said there was an off-site semen sample collection procedure in their clinic. Instructions for semen sample collection are available to patients at both off-site (69.4%) and on-site (93.9%) sample collection. Offering all patients with ICSI during the COVID-19 pandemic was one of the procedures performed at the IVF clinic in 69.4% of participants. A number of 80% of participants underwent individual zygote cultures after the ICSI procedure and 79.6% of participants performed repeated sperm washing methods before the sperm preparation procedure.

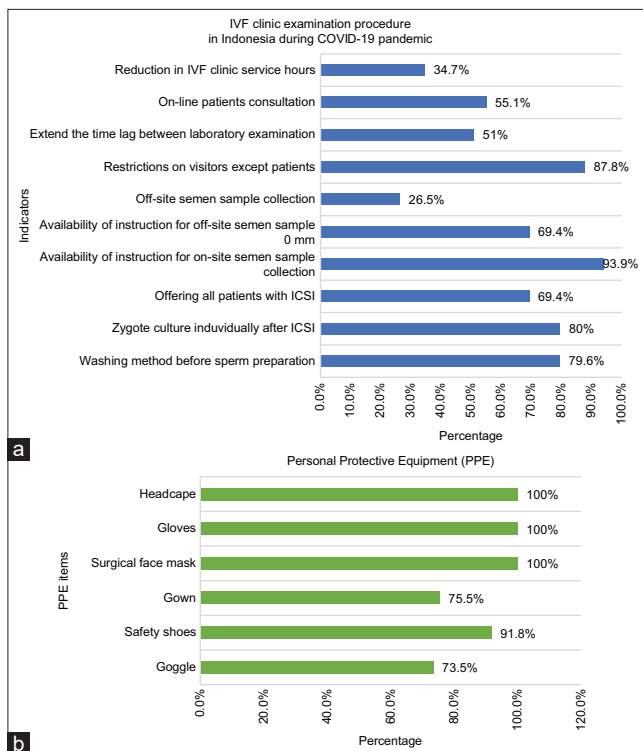


Figure 2: (a) IVF clinic examination procedure; (b) Personal protective equipment item used in the IVF laboratory

Use of personal protective equipment

We define full PPE in the IVF laboratory including the use of head cape, gloves, surgical face mask, gown, safety shoes, and goggles. The survey results are illustrated in Figure 2b. All participants (n = 49, 100%) used head capes, gloves, and surgical face mask while working in the IVF laboratory. A number of 75.5% of participants used gowns and 91.8% used safety shoes while working in the laboratory. A number of 73.5% used Goggles while working in the cryopreservation laboratory.

Laboratory equipment disinfection

Based on Figure 3a, 74% of participants separated laboratory equipment from suspected and non-suspected COVID-19 patients. There are written procedures for disinfection of laboratory equipment stated by 94% of participants. Laboratory equipment should be disinfected regularly. Some laboratory equipment that is disinfected regularly is shown in Figure 3b. The most regularly disinfected laboratory

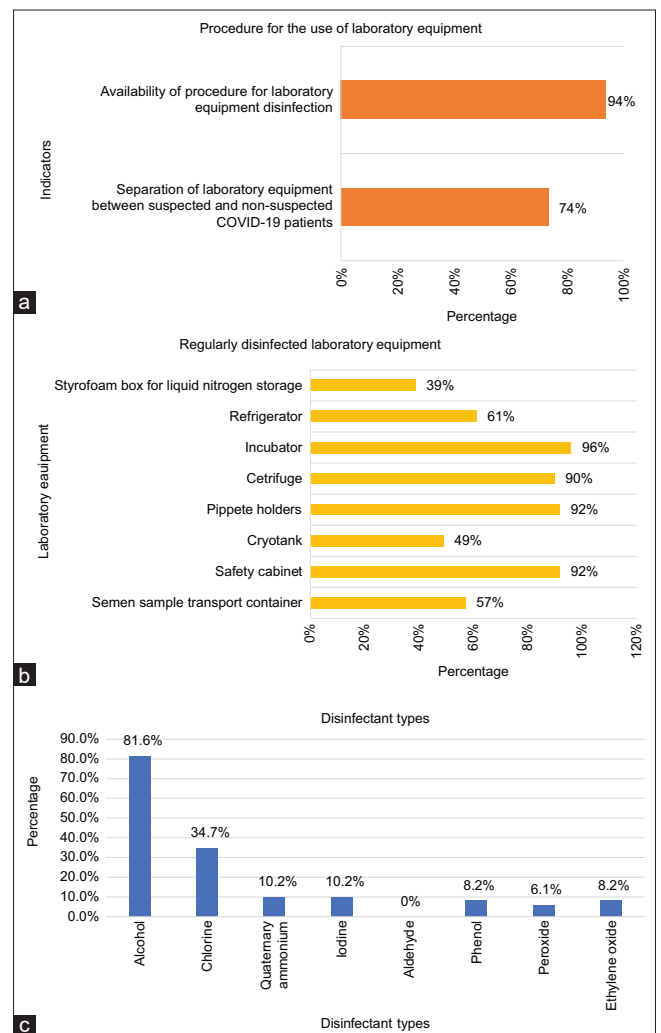


Figure 3: Laboratory equipment disinfection: (a) Procedure for the use of laboratory equipment; (b) Regularly disinfected laboratory equipment; (c) Disinfectant types used to disinfect laboratory equipment

equipment includes an incubator (96%), pipette holder (92%), safety cabinet (92%), and centrifuge (90%). Based on Figure 3c, it can be seen that the most widely used type of disinfectant is alcohol (81.6%).

In vitro fertilization clinic rooms disinfection

A number of 96% of participants stated that there was a procedure for IVF clinic rooms disinfection and 90% of them received socialization regarding the disinfection procedure as shown in Figure 4a. Based on Figure 4b, the most widely used type of disinfectant is alcohol (74%).

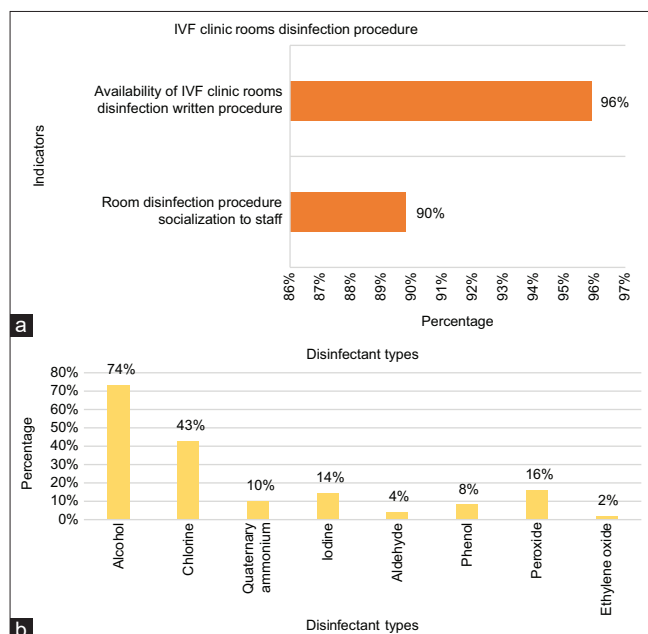


Figure 4: IVF clinic room disinfection: (A) IVF clinic rooms disinfection procedure. (B) Disinfectant types used to disinfect IVF clinic rooms

Discussion

We conducted a survey on IVF clinic services management in Indonesia, referring to several guidelines and preliminary studies that have been conducted in many countries in response to the COVID-19 pandemic. Based on the survey results, there have been several services adjustments made by IVF clinic management in response to the COVID-19 pandemic to minimize transmission of the virus in the IVF clinic. The IVF clinic management revised the service regulations as a form of adaptation to pandemic conditions. The patient services procedure was also undergone several adjustments, which aim to minimize the transmission of the virus in the IVF clinic.

Health care facilities management in Indonesia have given various responses to the COVID-19 pandemic which is still ongoing today. This also applied

to IVF clinics in Indonesia. Patient services changes were made by the IVF clinic management to minimize the risk of transmission of COVID-19 to staff and patients. The Ministry of Health as a national authority, as well as several organizations such as the CDC, ASRM, SART, and other sources highly recommends that each IVF laboratory/clinic conducting reviews for every service regulation and makes several adjustments for the patient's services according to the ongoing COVID-19 pandemic conditions [4].

To provide safe services for staff and patients, clinic management must make regulations related to service procedures in the clinic. Besides that, regulations for implementing health protocols during work must be made and obeyed by all staff. Socialization of regulations is needed, so that all staff know, understand, and apply them to work safely [4]. All IVF clinic managements in Indonesia have compiled regulations related to patient services and implementation of health protocols at work during the COVID-19 pandemic, and most have provided socialization to their staff (Figure 1a).

Staff in the IVF clinic should carry out an assessment of their own health conditions before starting to work. Patients who will visit the clinic for consultation or examination must also go through a screening process by officers. Each clinic has the authority to determine the patient screening method [4].

Health screening regulations for staff have been implemented in several IVF clinics in Indonesia (Figure 1B), and most of the IVF clinic managements in Indonesia provide officers at the clinic entrance to carry out body temperature checks for all staff and visitors (Figure 1B). Examination of body temperature is an initial screening method that is often used in various public facilities including hospitals. Although measuring body temperature is not a valid method of detecting COVID-19, the main benefit is that it is one of the easiest and cheapest methods for making a decision on whether a person can enter a hospital directly [11]. Most of the participants (83.7%) stated that their IVF clinic has specific officers in charge of screening the patient's condition via Whatsapp, email, and telephone (Figure 1C).

In ideal conditions, only patients who will undergo examination procedures or consultations are allowed to visit the clinic area. Partner or family members are allowed to enter the clinic area only under certain conditions that require their involvement in the examination process [4]. The survey result showed that several IVF clinics in Indonesia have limited the number of visitors during the COVID-19 pandemic (Figure 1C), this is done to reduce the crowd in the clinic area. Almost all IVF clinics in Indonesia have access to adequate hand washing stations and hand sanitizers in the clinic area. This makes regular hand hygiene practice easier for staff and visitors (Figure 1D). Hand hygiene is a highly recommended strategy for preventing the spread of COVID-19 in hospitals [12].

As an anticipatory step, IVF clinic managements should divide the staff into 2–3 mini teams based on the number of staff. If there is a staff in one of the teams who is infected or comes into contact with a COVID-19 patient, all staff in that team must be quarantined [9]. Not all IVF clinic managements in Indonesia divide their staff into mini teams, it was possible due to the limited number of staff (Figure 1b). Clinic management must ensure that all staff understand the process of COVID-19 transmission, in addition, risk mitigation training is necessary for staff as an initial response to the pandemic [4]. Some of the participants (53.1%) stated that they had received risk mitigation training of COVID-19 transmission (Figure 1b). This is a positive initial response that can be followed by all clinic management to reduce the potential for transmission of COVID-19 at the IVF clinic.

To minimize the COVID-19 transmission, the Indonesian Ministry of Health recommends separating entrances and exits in the hospital area [13]. Only 26.5% of participants stated that there were separate entrances and exits in their IVF clinic, this may be due to the limited clinic facility so it cannot be modified for access separation (Figure 1d). In the current pandemic condition, IVF clinic management needs to consider the policy of implementing off-site semen sample collection. This is done to shorten patients' time in the clinic. Patients should be given clear instructions regarding the procedure of sample collection, provide sample identification, and the process for transporting the sample to the clinic [4]. Off-site semen sample collection is rare in Indonesia. It is possible that the distance between the patient's house and the clinic will affect the results of sperm analysis. In addition, there is a risk that the sample sent does not belong to the patient.

The use of telecommunications technology (telemedicine) to support long-distance health services has been carried out by several health service providers for a long time. However, the wide application was not carried out until the COVID-19 pandemic occurred [14]. To minimize the patient as a potential source of viral contamination, face-to-face contact with the patient is minimized whenever possible. Laboratory staff are advised to communicate by telephone or other communication alternatives such as Email and video calls [4]. In the telemedicine implementation, there are several obstacles including technical barriers and limited internet network access for some patients [15]. This is the reason why not all IVF clinics in Indonesia implement online consultation services.

Staff working in the IVF laboratory must wear appropriate PPE including a head cap, surgical mask, scrubs/gown, and gloves [4]. Most IVF laboratory managements from the previous survey stated that they agreed with the use of goggles while working in the laboratory, especially when using a microscope or

micromanipulation [5]. Goggles are important to use while working in the laboratory, especially those related to body fluids, blood, etc. because it can protect the eye mucosa [16]. Besides that, the use of footwear was also important while working in the IVF laboratory [5]. From the present study, the use of head capes, gloves, and surgical masks was done by all participants, whereas not all laboratory staff in this study used gowns, safety shoes, and goggles while working in the laboratory.

IVF clinic managements must establish a disinfection policy including disinfection procedures, frequency, and type of disinfectant. Disinfection is carried out on all laboratory equipment and clinical procedure rooms. The type of disinfectant used in the laboratory must be safe for embryo development [4]. The presence of volatile organic compounds (VOCs) in the disinfectant can be harmful to embryo development *in vitro* [17]. The previous study has suggested the use of quaternary ammonium solutions for laboratory disinfection that are considered VOCs and embryo-toxin free [5]. Most IVF clinics use ethanol as a disinfectant which is a known type of VOC. To overcome this, adequate air filtering is required in the IVF laboratory which can filter out hydrocarbon pollutants, chemically active components, and pathogens [18].

Conclusions

Several adjustments were made by IVF clinic management in Indonesia as an early response to the COVID-19 pandemic. Clinic managements compile several adjustments to the service regulations during the COVID-19 pandemic as one of the readiness of IVF clinics in providing safe services for patients and staff. The use of PPE, disinfection of laboratory equipment and rooms, and implementation of health protocols in the workplace are aimed to minimize transmission of COVID-19 in IVF clinics. Some adjustments have not been implemented in several IVF clinics for some reasons such as separation of entry and exit access of clinics, dividing staff into mini teams, training the staff in COVID-19 transmission risk mitigation, and implementing off-site semen sample collection.

References

1. Yuen KS, Ye ZW, Fung SY, Chan CP, Jin DY. SARS-CoV-2 and COVID-19: The most important research questions. *Cell Biosci.* 2020;10(1):40. <https://doi.org/10.1186/s13578-020-00404-4>
2. Schett G, Sticherling M, Neurath MF. COVID-19: Risk for cytokine targeting in chronic inflammatory diseases? *Nat Rev Immunol.* 2020;20(5):271-2. <https://doi.org/10.1038/s41577-020-0312-7> PMID:32296135

3. Force ICT. COVID-19 Situation in Indonesia Jakarta, Indonesia: Indonesian COVID-19 Task Force; 2021. Available from: <https://www.covid19.go.id> [Last accessed on 2021 Mar 10].
4. ASRM. Laboratory Guidance for Commencing or Continuing ART Operations During the Ongoing COVID-19 Pandemic 2020. Available from: <https://www.asrm.org/news-and-publications/covid-19/covid-19-press-releases-and-announcements/updated-document-laboratory-guidance-for-commencing-or-continuing-art-operations-during-the-ongoing-covid-19-pandemic> [Last accessed on 2021 Mar 10].
5. Hickman C, Rogers S, Huang G, MacArthur S, Meseguer M, Nogueira D, *et al.* Managing the IVF laboratory during a pandemic: International perspectives from laboratory managers. *Reprod BioMed Online*. 2020;41(2):141-50. <https://doi.org/10.1016/j.rbmo.2020.05.006> PMID:32622702
6. Rizal D. Adjustment of sperm cryopreservation laboratory management during the COVID-19 pandemic. *J Med Sci*. 2021;53(1):9. <https://doi.org/10.19106/jmedsci005301202106>
7. Li D, Jin M, Bao P, Zhao W, Zhang S. Clinical characteristics and results of semen tests among men with coronavirus disease 2019. *JAMA Network Open*. 2020;3(5):e208292. <https://doi.org/10.1001/jamanetworkopen.2020.8292> PMID:32379329
8. ISHE. IVF Clinic Data Until 2020 Data Klinik IVF di Indonesia Tahun 2020. Yogyakarta: Indonesian Society of Human Embryology; 2020.
9. Andrabi SW, Jaffar M, Arora PR. COVID-19: New adaptation for IVF laboratory protocols. *JBRA Assist Reprod*. 2020;24(3):358-61. <https://doi.org/10.5935/1518-0557.20200054> PMID:32598835
10. Maggiulli R, Giancani A, Fabozzi G, Dovere L, Tacconi L, Amendola MG, *et al.* Assessment and management of the risk of SARS-CoV-2 infection in an IVF laboratory. *Reprod BioMed Online*. 2020;41(3):385-94. <https://doi.org/10.1016/j.rbmo.2020.06.017> PMID:32693991
11. Dzien C, Halder W, Winner H, Lechleitner M. Covid-19 screening: Are forehead temperature measurements during cold outdoor temperatures really helpful? *Wiener klinische Wochenschrift*. 2021;133(7-8):331-5. <https://doi.org/10.1007/s00508-020-01754-2> PMID:33095321
12. Lotfinejad N, Peters A, Pittet D. Hand hygiene and the novel coronavirus pandemic: The role of healthcare workers. *J Hosp Infect*. 2020;105(4):776-7. <https://doi.org/10.1016/j.jhin.2020.03.017> PMID:32201339
13. Indonesian Ministry of Health, Kementrian Kesehatan Republik Indonesia. Technical Guidelines for Hospital Services in The New Normal Adaptation Pedoman Pelayanan Rumah Sakit Pada Masa Pandemi Covid-19. Jakarta: Indonesian Ministry of Health; 2020.
14. Kronenfeld JP, Penedo FJ. Novel coronavirus (COVID-19): Telemedicine and remote care delivery in a time of medical crisis, implementation, and challenges. *Transl Behav Med*. 2020;11(2):659-63. <https://doi.org/10.1093/tbm/ibaa105> PMID:33098426
15. Kruse CS, Karem P, Shifflett K, Vegi L, Ravi K, Brooks M. Evaluating barriers to adopting telemedicine worldwide: A systematic review. *J Telemed Telecare*. 2018;24(1):4-12. <https://doi.org/10.1177/1357633x16674087> PMID:29320966
16. Qu JM, Cao B, Chen RC. Prevention and Disease Control of COVID-19. United States: Centers for Disease Control and Prevention; 2021. p. 75-88. <https://doi.org/10.1016/b978-0-12-824003-8.00006-1>
17. Agarwal N, Chattopadhyay R, Ghosh S, Bhounik A, Goswami SK, Chakravarty B. Volatile organic compounds and good laboratory practices in the in vitro fertilization laboratory: The important parameters for successful outcome in extended culture. *J Assist Reprod Genet*. 2017;34(8):999-1006. <https://doi.org/10.1007/s10815-017-0947-x> PMID:28540437
18. Khoudja RY, Xu Y, Li T, Zhou C. Better IVF outcomes following improvements in laboratory air quality. *J Assist Reprod Genet*. 2013;30(1):69-76. <https://doi.org/10.1007/s10815-012-9900-1> PMID:23242648