Preventing laboratory-associated infections in the COVID-19 era: experience from a tertiary care infectious disease hospital in Southern Vietnam

Man Dinh Nguyen Huy
The Hospital for Tropical Diseases
Ngoc Nghiem My
The Hospital for Tropical Diseases
Hoang Dang Minh
Oxford University Clinical Research Unit,
Trang Nguyen Hoa
Oxford University Clinical Research Unit,
Thao Duong Thi Phuong
Oxford University Clinical Research Unit,
Hang Vu Thi Ty
Oxford University Clinical Research Unit,
Tan Le Van
Oxford University Clinical Research Unit,
Nga Nguyen Thi Quynh
The Hospital for Tropical Diseases
Dung Nguyen Thanh
The Hospital for Tropical Diseases
Hung Le Manh
The Hospital for Tropical Diseases
Thai Pham Quang
National Institute of Hygiene and Epidemiology, Hanoi, Vietnam
Chau Nguyen Van Vinh
The Hospital for Tropical Diseases
Guy Thwaites
Oxford University Clinical Research Unit, Vietnam
Marc Choisy
Oxford University Clinical Research Unit, Vietnam
Motiur Rahman (mrahman@oucru.org)
Oxford University Clinical Research Unit, Vietnam https://orcid.org/0000-0002-6702-5355

Method Article

Keywords: COVID-19, SARS CoV-2, Laboratory-associated infection, Biosafety, Vietnam, Laboratory

Posted Date: October 30th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-100413/v1

Abstract

Background: Laboratory staff is at higher risk of infection owing to the handling and testing of coronavirus disease 2019 (COVID-19) patient samples. Reviewing the existing risk assessment and improving risk management are essential for preventing laboratory acquired infections (LAIs) related to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) testing during the COVID-19 epidemic. We present herein the steps taken to prevent LAIs related to SARS-CoV-2 testing in a tertiary care hospital in Vietnam.

Methods: A SARS-CoV-2-focused risk assessment exercise was conducted for laboratory processes and workflow. Risk management strategies, including engineering, administrative and operations control procedures, were established. Standard operating procedure (SOP), staff training, COVID-19 symptom reporting, enhanced cleaning and decontamination, and inventory monitoring protocols were implemented. Sample reception and results reported from February 1, 2020 to September 17, 2020 were documented.

Results: Based on risk assessment, a risk management strategy for SARS-CoV-2 testing was developed. This strategy includes the use of dedicated facility, instrument, and cold chain units for testing; SOPs; training (testing, decontamination and cleaning staff); the introduction of biosafety level (BSL)2^{+} laboratory practices; enhanced cleaning protocols for testing; and the assigning of additional staff for testing and safety system implementation. In total, 38,377 (daily mean and range: 166; 3 – 2,377) samples were received, including 301 (0.8%) samples that were rejected. The turnaround time (median ± standard deviation (SD)) was 3.54 ± 2.97 days. Altogether, 32 staff members were involved with SARS-CoV-2 testing and biosafety management, and there were no reports of COVID-19 symptoms among them.

Conclusion: For epidemics and outbreak diagnostics, risk assessment and risk management strategies are important for the prevention of LAIs. Clear instruction on revised risk management protocols, necessary training, and leadership in risk management strategy implementation are essential.

Background

On January 30, 2020, the World Health Organization declared coronavirus disease 2019 (COVID-19) a public health emergency of international concern [1]. Since then, 28,956,415 people from 215 countries and territories have been infected with COVID-19 as of 14th September (https://www.worldometers.info/coronavirus/). During the ongoing COVID-19 pandemic, health-care workers (HCW), including laboratory workers, are at a substantially increased risk of becoming infected with Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) due to direct possible contact with COVID-19 patient samples [2]. This risk has been increased by the need to rapidly scale up testing facilities by recruiting new staff, (e.g., newly qualified students or laboratory technicians) to the laboratory workforce in response to the pandemic [3] [4]. Laboratory staff can acquire SARS-CoV-2 at work through direct or indirect contact with infected patient samples or other health-care workers or as a result of ongoing community transmission [4]. Community transmission of SARS-CoV-2 is targeted by various public health measures (lockdown, social distancing, mask use, frequent hand washing, working from home), whereas infection by patient samples or contaminated surface contact is primarily addressed by facility-based infection prevention and control (IPC) and biosafety measures [5].

Laboratory personnel can be exposed to SARS-CoV-2 through i) clinical specimen reception (packed inside specimen carrier bags); ii) unpacking and accessing COVID-19 specimens; iii) specimen transportation from the specimen reception area (SRA) to designated Biological Safety Level (BSL) 2 laboratories for further processing; iv) disposal of items associated with COVID-19 specimens; v) sample manipulation from primary containers; vi) inactivation of COVID-19 samples; vii) conducting diagnostic assays; and viii) waste disposal after testing [5]. Contact transmission is one of the main routes of SARS-CoV-2 transmission. Transmission from patients to HCWs usually follows contamination of the HCWs' hands after touching either patients, samples or fomites, and hand hygiene is considered the most important prevention measure for healthcare-associated infections [6]. To protect laboratory staff from laboratory-acquired COVID-19 infection, several guidelines have been issues by The World Health Organization, US CDC [7, 8] and individual countries. These guidelines have provided a framework for primary and secondary containment requirements, personal protective equipment (PPE), and laboratory practices to prevent laboratory-acquired infections (LAIs) during SARS-CoV-2 testing. However, it is necessary to conduct a risk assessment of laboratory processes and workflow to develop a risk management strategy to ensure biosafety for SARS-CoV-2 testing.

Vietnam is a low-middle income country (97.3 million population) and was one of the first countries affected by SARS-CoV-2, recording its first case on January 23, 2020. The response to epidemics (health status screening at border gates; tracing and quarantining of suspected cases and their contacts; monitoring of suspected cases of respiratory infections; and mass communication on preventive measures, including hand washing, contact avoidance and mask wearing) was swift, timely and well-coordinated [9]. Vietnam has achieved remarkable success in containing the COVID-19 epidemic, with 1095 cases and 35 deaths as of September 30, 2020. However, Vietnam has also encountered two major SARS-CoV-2 outbreaks in hospital settings (the first was in Hanoi (45 confirmed cases) and the second in three hospitals in Da Nang city (129 patients, including 30 health care workers and 35 deaths)) in central Vietnam.

The implementation of biosafety risk assessment and risk management is essential for preventing LAI in SARS-CoV-2 testing laboratories. While there is ample information on IPC for the clinical management of COVID-19 patients, data on risk assessment and biosafety risk management system implementation for laboratories performing SARS-CoV-2 testing are limited. Herein, we present the biosafety risk assessment process and management strategies implemented in SARS-CoV-2 sample reception, testing and results reporting at the Hospital for Tropical Diseases, Ho Chi Minh City, Vietnam during the first 8 months of the COVID-19 epidemic.

Material And Methods

We report a prospective, descriptive documentation on the operation and biosafety process management of SARS-CoV-2 analytic processes in the Molecular Diagnostic Laboratory (MDL) of the Hospital for Tropical Diseases (HTD) and Oxford University Clinical Research Unit (OUCRU), Ho Chi Minh City, Vietnam, from February 1 to September 17, 2020. We present the risk assessment and risk management for laboratory processes (pre-analytic, analytic and post analytic) and document the number of samples received, tested and reported during the study period.

Setting and laboratory

The Hospital for Tropical Diseases (HTD), Ho Chi Minh City is a 650-bed infectious disease hospital and a designated specialized care provider and referral centre for patients infected with SARS-CoV-2 from the central and south of Vietnam [10]. The hospital laboratory is a Ministry of Health (MoH) designated SARS-CoV-2 real-time PCR (RT-PCR) testing centre. HTD, in partnership with OUCRU, maintains clinical and research laboratories. The laboratories includes a BSL2 clinical laboratory (ISO 15189 certified since 2008), a BSL2 research laboratory (Good Clinical Laboratory Practice (GCLP)-compliant and MoH-certified BSL2 since 2014) and a BSL3 and Specified Animal Pathogen Order 4 (SAPO4) laboratory (MoH-certified since 2013) [11].

Risk assessment and risk management

A SARS-CoV-2-focused risk assessment exercise was conducted to develop the risk management strategy. The risk assessment includes all laboratory processes (pre-analytic, analytic and post-analytic) for SARS-Cov-2 testing. Based on risk assessment, a risk management strategy for SARS-CoV-2 was developed and implemented. Biosafety compliance monitoring was introduced to ensure compliance with SOPs and with the local regulations. A laboratory training programme was implemented for all staff involved in COVID-19 sample testing processes. An internal and external quality assurance programme, including inter-laboratory comparisons, was implemented to ensure the quality of testing. The laboratory certification for SARS-CoV-2 testing and biosafety was conducted by the Department of Health (DoH) and HCM CDC.

Self-reporting of COVID-19 symptoms (fever, cough, sore throat and similar symptoms of any family member) was implemented for staff working with suspected SARS-CoV-2 samples starting in January. An electronic COVID-19 symptoms reporting system was introduced in August. A laboratory logistic and PPE stock monitoring system, including minimum stock for reordering, was implemented to ensure availability of stocks.

Sample reception and testing

All samples received for SARS-CoV-2 testing were registered in the HTD laboratory database. All data extracted from the hospital database were analysed using Statistical Package for Social Science (SPSS) software (IBM SPSS Statistics 23, NY USA). We analysed the data for the number of samples received daily, the samples tested, and the reports delivered. Sample rejection was calculated by deducting the samples received and samples sent for analysis. Samples sent to other laboratories for testing were calculated by deducting the samples received and reports not submitted by HTD. Turnaround time was calculated by subtracting the sample receiving date and time to the report delivery date and time. The total number of samples tested for COVID-19 in HCM city and the COVID-19 outbreak information data were collected from the National COVID-19 database maintained by the National Institute of Hygiene and Epidemiology (NIHE).

Results

National strategy for SARS-CoV-2 testing.

The national COVID-19 testing strategy was implemented for SARS-CoV-2 testing at HTD [12]. The real-time (RT)-PCR assay is considered as a confirmatory test. Two swabs are collected (one nasopharyngeal and one throat) from each patient and stored in viral transport media (VTM). Samples in VTM are stored at 4ºC and transported to the laboratory using triple layer packing. Chain of custody and sample information documents are packed separately and transported to the laboratory along with the samples [13].

Risk assessment and risk management

The risk assessment includes pre-analytic (sample handling after receiving, examining for acceptance criteria, and organizing for analytic process), analytic (sample inactivation, nucleic acid extraction and RT-PCR assay) and post-analytic (data retrieval, report generation, reporting, and storage or destruction of samples) processes. Risk management includes engineering (infrastructure, facility, workflow, primary and secondary containment), administrative (SOPs, PPE, and disinfectants), operational process controls (training, facility decontamination, waste management, LAI reporting, logistics, and safety compliance monitoring), and monitoring of the implementation (Table 1). As a part of the risk management strategy, HTD and OUCRU shared the laboratory infrastructure, logistics, and human resources and worked together to ensure the quality, safety and timely testing of the SARS-CoV-2 samples. This includes sharing

infrastructure and facilities (e.g., specimen reception room, cold chain units (2-8 ºC and -86 ºC freezer), molecular diagnostic facility, BSL3 laboratory), instruments, manpower and safety system implementation.

Risk management includes the spraying of sample containers (outer containers) with freshly prepared disinfecting solution (chlorine 1000 ppm) and opening secondary containers in biosafety cabinets (BSC) Class (Cl) I to examine acceptance criteria. PPE used for sample reception area includes reusable lab coats (equivalent to AAMI level 2), surgical face masks (equivalent to American Society for Testing and Materials (ASTM) level 2), nitrile gloves, goggles, hair caps, and shoe covers. The specimen reception facility is decontaminated 3 times daily (7:00 AM, 1:00 PM and 5:00 PM) with Virkon S (Peroxygen 49.8%, Sodium chloride 27.6%; 10 g/L) disinfectant (10 g/L) sprayed with an ultra-low volume sprayer at a dose of 20 to 30 mL/m^2. Waste is stored in double bags and removed before each decontamination cycle. Samples are transported to MDL in batches and inactivated in the BSL2 laboratory in BSC Cl I following $BSL2^+$ laboratory practices. $BSL2^+$ laboratory practice includes disposable PPE, including fit-tested particulate respirators (equivalent to an N95 mask), long-sleeved gowns (equivalent to AAMI level 3), goggles, round caps, latex gloves and shoe covers. All aerosol generating procedures are conducted in BSCs and centrifugation in sealed buckets. The MDL was decontaminated 5 times daily (7:00 AM, 11:00 AM, 3:00 PM, 6:00 PM and 11:00 PM) with Virkon S (10 gm/L) sprayed with an ultra-low volume sprayer at a dose of 20 to 30 mL/m^2. In the laboratory, all BSCs are cleaned with Surfanios (DD BioLab, Barcelona, Spain) after use and irradiated with UV light once a day for 2 hours. Waste is stored in double bags and removed before each decontamination cycle.

Test results were extracted from the instruments through a laboratory information system (LIS) and evaluated for quality. The results were rejected if controls failed or if there were signs of carry-over contamination. The results were reviewed, transcribed to test report forms and delivered to the CDC, Ho Chi Minh City. Remaining SARS-CoV-2 positive or negative samples were stored in the BSL3 biorepository or destroyed, respectively. The heating, ventilation and air conditioning (HVAC) system of the facility was set at 26 ºC, with 6-8 air changes per hour.

SOPs for SARS-CoV-2 testing processes, including sample reception, acceptance and rejection criteria, chain of custody, sample inactivation, TNA extraction, and sample retention/destruction, were developed. All SOPs and training presentations were bilingual (English and Vietnamese) and were posted in the OUCRU portal for easy access. A training programme was implemented for staff working with SARS-CoV-2 testing, including sample reception, testing, facility decontamination, waste management and janitors. The training included risk assessment, biosafety, PPE use (donning and doffing), and the assignment process (e.g., sample reception, sample inactivation, total nucleic acid (TNA) extraction, PT-PCR assay, facility decontamination, waste management and sample destruction). Overall, 14 clinical laboratory staff (4 staff for pre-analytic, 8 staff for analytic and 2 staff for post-analytic processes) were responsible for SARS-CoV-2 testing. In addition to this, 4 laboratory staff members from Children's Hospital No. 1 and 8 research laboratory staff members were involved in SARS-CoV-2 testing during the high sample load periods. Additionally, 6 OUCRU laboratory management staff members were involved in safety process implementation. None of the staff involved in sample reception, testing, facility decontamination or cleaning reported any symptoms of COVID-19.

MDL was certified by the Department of Health (DoH), HCM on March 14, 2020 for SARS-CoV-2 testing. External audits were conducted by HCM city CDC in early September. An inter-laboratory comparison programme was implemented for the initial two months of testing, where all positive samples were retested at Pasteur institute in HCM city. No discrepancies were identified between the two laboratories. The OUCRU laboratory management team conducted daily inspections of the facilities. All instruments, including BSC, TNA extraction system, real-time PCR systems, freezers and refrigerators, were maintained and calibrated as per GCLP standards. All processes implemented are in compliance with the laboratory safety for SARS-CoV-2 testing from the Ministry of Health (MoH) of Vietnam.

A logistic management system for PPE and diagnostic reagents were implemented. A bulk procurement for 20,000 SARS-CoV-2 diagnostic tests was initiated in March 2020, and procurement was continued as per need. For PPE (surgical mask, N95 mask, disposable lab coat, nitrile gloves) disinfectants, and hand sanitizers, 3 months stock was considered sufficient.

Sample testing and reporting

SARS CoV-2 samples were collected in different locations, including i) designated infectious diseases hospitals for COVID-19; ii) makeshift hospitals for COVID-19 patients; iii) quarantine facilities; iv) local lockdown communities; and v) field investigation sites. Samples were collected for screening of patients, confirmation of COVID-19 diagnosis or confirmation of cure. All samples received for SARS-CoV-2 testing were registered in the clinical laboratory database. Respiratory and oropharyngeal samples for RT-PCR were tested in MDL, and blood samples for clinical haematology and biochemistry tests were processed in a routine clinical laboratory. Respiratory and oropharyngeal samples for microbiology culture were performed in the BSL3 microbiology laboratory.

During the reporting period, there were two local outbreaks that influenced the number of samples and tests. The first occurred from March 24 to April 13, 2020, mostly in Hanoi and around the north, and in Ho Chi Minh City in the south of the country. The second occurred from July 28 to August 8, 2020, mostly in and around Da Nang in the centre of the country (Fig 1).

From February 1, 2020 to September 17, 2020, 38,377 samples were received for testing (Table 2), accounting for 18.6% (38,377/206,626) of all tests done in Ho Chi Minh City during the reporting period. Among these 38,377 samples, 301 (0.8%) were rejected as they did not fulfil the acceptance criteria. The mean number of samples received per day was 166, with a range of 3 to 2,377. The turnaround time (mean ± SD) for SARS-CoV-2 testing in our hospital was 3.54 ± 2.97 days (1.30 ± 1.23 during the non-outbreak period and 4.55 ± 2.99 during the outbreak period) (Fig 1). During the first (March 24 to April 13) and second (July 28 to August 8) outbreaks, the numbers of samples received (mean and range) were 11,904 and 14,293, with daily numbers of 626 (106-2,061) and 1050 (34-2,377), respectively (Table 2). Overall, 4,924 (12.8%) samples were sent to other laboratories for testing during the outbreak periods (2,648 during the first and 2,276 during the second outbreak).

Discussion

COVID-19 has significantly increased the workload for healthcare workers, including laboratory staff. Most clinical laboratories were not equipped to address the testing requirements of epidemics, such as COVID-19. Public hospital clinical laboratories are often understaffed and lack necessary high throughput instruments to address sample testing during epidemics. For most clinical laboratories, upgrading the laboratory facility for epidemic diagnostic needs is a challenge. Laboratories need to install new instruments, implement new methods and train new staff to address the increasing demand for testing. The collaboration between OUCRU and HTD (manpower, equipment, facility, and quality and safety system implementation) in COVID-19 diagnostics played a key role in conducting the tests in a timely manner and ensuring quality and safety associated with SARS-CoV-2 testing. This includes planning for testing scenarios (non-outbreak and outbreak), resource allocation (personnel, logistics and supplies), and quality and safety system implementation rollouts. The research specimen reception room and research MDL were dedicated for SARS-CoV-2 testing during high sample load situations. The OUCRU research staff, laboratory safety implementation team and waste management team provided support whenever necessary. During the outbreak period, a large number of samples was assigned to HTD, which was beyond the capacity of the hospital. Having a back-up assigned laboratory helped to overcome the situation.

The contagious nature of SARS-CoV-2 added an additional dimension to the challenge. The laboratory personnel were concerned from their perception of the potential risks of becoming infected with SARS-CoV-2 and developing COVID-19 during their laboratory work, which involved possible aerosol-generating procedures, surface contamination and environmental contamination in the laboratories. At OUCRU, we conducted SARS-CoV-2-focused risk assessment and workflow analysis with laboratory staff and developed a risk management strategy by addressing their concerns. We reduced the major risks through the engineering, administrative, and operation controls, and the residual risk for various laboratory activities was addressed by laboratory practices and PPE.

Training plays a key role in successful implementation of any biosafety programme in the laboratory. OUCRU maintains a BSL3 laboratory and has developed a team of biosafety trained laboratory staff over the years. These staff members (laboratory and biosafety management) played a major role in implementing biosafety and scaling up the SARS-CoV-2 testing in HTD. Additionally, OUCRU maintains a critical stock of logistics and PPEs as part of an epidemic preparedness programme. Those stocks played an important role in maintaining a constant supply of logistics and PPE.

During the reported period, the hospital received (mean and range) 166 (3-2377) additional samples on top of their routine samples. During the outbreak period, additional staff members were assigned to ensure sample reception and testing. We observed an increase in sample rejection during the second outbreak, which might have been due to the recruitment of new staff for sample collection or poor sample management before sending to the laboratory. The laboratory could not analyse all the samples received for testing due to the time required for sample sorting and organization in pre-analytic processes. The time for pre-analytic processing is often underestimated. Similarly, the turnaround time for SARS-CoV-2 testing increased during the outbreak period because the sample volume exceeded the limit of testing capacity. Therefore, a clear determination of the testing capacity before sample assignment to a laboratory is critical.

Challenges in safety system implementation

There were several challenges in the operation. Maintaining access control was a challenge as samples were shipped to laboratory 24 hours a day and 7 days a week. DoH assigned personnel from other hospitals to support the SARS-CoV-2 diagnosis. However, training of these staff members in a short time was a challenge. Sorting of specimens sent from different sites and organizing them for testing was another major challenge and was one of the causes for delays in turnaround time and samples being sent to other institutes for testing. Securing logistics for diagnostic kits, reagents, and PPE was another challenge. Limited flight options for importing reagents and kits, production delays due to COVID-19 lockdown, PPE hording by local suppliers, and price hiking are a few examples. SARS-CoV-2 testing was an additional workload (generally MDL conducts 250-300 tests/day) to the routine work of the laboratory staff, and staff had to work longer hours to cope with these duties. This, along with staying away from family for long hours, has stressed the laboratory staff. Maintaining quality of the testing and ensuring the safety of laboratory staff was also a challenge. Often, it was difficult to implement all safety measures and conduct the assigned number of tests. Therefore, during the outbreak period, the turnaround time was significantly increased.

Conclusion

Infectious disease epidemics pose a significant biosafety risk and increase the probability of LAIs. Pathogen-specific risk assessment and risk management strategies should be implemented to address these risks. Clear strategies on risk management and support for exposed and infected laboratory workers are essential to ensure trust in the workplace. These management strategies should include monitoring for LAIs and decision making about immediately implementing essential safety measures when necessary.

Abbreviations

AAMI	Association for the Advancement of Medical Instrumentation
ASTM	American Society for Testing and Materials
COVID-19	Coronavirus disease 2019
BSL	Biosafety level
BSC	Biosafety cabinet
CL	Class
DoH	Department of Health
GCLP	Good Clinical Laboratory Practice
HTD	Hospital for Tropical Diseases
HCW	Health-care workers
IPC	infection prevention and control
LAIs	Laboratory Acquired Infections
LIS	Laboratory information system
MoH	Ministry of Health
NIHE	National Institute of Hygiene and Epidemiology
OUCRU	Oxford University Clinical Research Unit
PPE	Personal protective equipment
RT	Real-time
SAPO	Specified Animal Pathogen Order
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus 2
SOP	Standard Operating Procedure
SD	Standard deviation
SRA	Specimen reception area
SPSS	Statistical Package for Social Science
TNA	Total nucleic acid
VTM	Viral transport media

Declarations

Ethics approval and consent to participate: Not applicable. The article did not involve enrolment of any humans, animals or plants. The article describes the laboratory processes. The Hospital for Tropical Diseases ethical review committee ruled that no formal ethics approval was required for this article and waived the need for consent.

Consent for publication: Not applicable

Availability of data and materials: All data and materials used for this publication are available under the OUCRU data sharing policy and can be requested at DAC@oucru.org

Competing interests: There are no competing interests

Funding: No external funding was received for this project

Authors' contributions:

MDNH: Data collection, manuscript review, implementation; NNM: Implementation, data analysis, manuscript drafting; HDM: implementation, data collection, manuscript review; TNH: data collection and data analysis, manuscript drafting and review; TDHP: implementation, data collection and analysis, manuscript drafting; HVTT: implementation, manuscript drafting, data collection; TLV: supervision of implementation, drafting and manuscript review; NNTQ: implementation, study design, manuscript review; DNT: Study design, data collection, study supervision, manuscript review; HLM: Study design, data collection, study supervision, manuscript review; TPQ: data collection and analysis, study design, manuscript drafting; CNVV: study design, supervision, manuscript review; GT: study design, supervision, manuscript review; MC: study planning, design and manuscript drafting; MR: planning, design and manuscript drafting.

All authors have read and approved the manuscript

Acknowledgements:

This study was supported by the Oxford University Clinical Research Unit, Vietnam. We thank all members of the HTD COVID-19 laboratory team and OUCRU COVID-19 research group. We also thank all laboratories who contributed testing information in the COVID-19 test result database.

OUCRU COVID-19 Diagnostic and Lab management team: Huynh Le Anh Huy, Huynh Xuan Yen, Lam Anh Nguyet, Tran Tan Thanh, Le Nguyen Truc Nhu, Le Van Tan, Motiur Rahman, Nguyen Thi Han Ny, Nguyen Thi Kim Tuyen, Nguyen Thi Thu Hong, Le Kim Thanh, Phung Le Kim Yen, Vu Thi Ty Hang, Dang Minh Hoang, Duong Thi Phuong Thao, Nguyen Hoa Trang, Ho Van Sung, Dinh Thanh Phong, Le Pham Minh Tu, Cao Thu Thuy, and Tran Thi Bich Chieu.

HTD COVID-19 Diagnostic and Lab management team: Nguyen Van Vinh Chau, Nguyen Thanh Dung, Le Manh Hung, Dinh Nguyen Huy Man, Nguyen Thi Quynh Nga, Nghiem My Ngoc, Pham Thi Ngoc Thoa, Tran Nguyen Phuong Thao, Tran Thi Lan Phuong, Le Thi Tam Uyen, Tran Thi Thanh Tam, Bui Thi Ton That, Huynh Thi Kim Nhung, Ngo Tan Tai, and Vo Trong Vuong.

References

1. Zuckerman NS, Pando R, Bucris E, Drori Y, Lustig Y, Erster O, Mor O, Mendelson E, Mandelboim M: **Comprehensive Analyses of SARS-CoV-2 Transmission in a Public Health Virology Laboratory**. *Viruses* 2020, **12**(8).
2. Sikkema RS, Pas SD, Nieuwenhuijse DF, O'Toole A, Verweij J, van der Linden A, Chestakova I, Schapendonk C, Pronk M, Lexmond P *et al*: **COVID-19 in health-care workers in three hospitals in the south of the Netherlands: a cross-sectional study**. *Lancet Infect Dis* 2020.
3. Zheng L, Wang X, Zhou C, Liu Q, Li S, Sun Q, Wang M, Zhou Q, Wang W: **Analysis of the infection status of the health care workers in Wuhan during the COVID-19 outbreak: A cross-sectional study**. *Clin Infect Dis* 2020.
4. Bielicki JA, Duval X, Gobat N, Goossens H, Koopmans M, Tacconelli E, van der Werf S: **Monitoring approaches for health-care workers during the COVID-19 pandemic**. *Lancet Infect Dis* 2020.
5. Wong CK, Tsang DN, Chan RC, Lam ET, Jong KK: **Infection Risks Faced by Public Health Laboratory Services Teams When Handling Specimens Associated With Coronavirus Disease 2019 (COVID-19)**. *Saf Health Work* 2020.
6. Bloise I, Gomez-Arroyo B, Garcia-Rodriguez J, Group SA-C-W: **Detection of SARS-CoV-2 on high-touch surfaces in a clinical microbiology laboratory**. *J Hosp Infect* 2020, **105**(4):784-786.
7. Organization WH: **Laboratory biosafety guidance related to coronavirus disease (COVID-19)**. In., vol. WHO/WPE/GIH/2020.3. Geneva, Switzerland World Health Organization; 2020.
8. Prevention CfDCa: **Guidance for General Laboratory Safety Practices during the COVID-19 Pandemic**. In. Atlanta, USA: Centers for Disease Control and Prevention; 2020.
9. Pham QT, Rabaa MA, Duong HL, Dang QT, Tran DQ, Quach HL, Hoang NT, Phung CD, Ngu DN, Tran AT *et al*: **The first 100 days of SARS-CoV-2 control in Vietnam**. *Clin Infect Dis* 2020.
10. Nguyen Thanh Dung TTTT, Nghiêm Mỹ Ngọc, Lê Thanh Phuông, Vo Minh Quang, Motiur Rahman and Lê Mạnh Hùng: **Baseline characteristics and cost of treatment for chronic hepatitis C patients attending at Hospital for Tropical Disease, Ho Chi Minh City, Vietnam; Real world data in Direct Acting Antiretroviral treatment era.** . In.; 2019.
11. Wertheim HF, Puthavathana P, Nghiem NM, van Doorn HR, Nguyen TV, Pham HV, Subekti D, Harun S, Malik S, Robinson J *et al*: **Laboratory capacity building in Asia for infectious disease research: experiences from the South East Asia Infectious Disease Clinical Research Network (SEAICRN)**. *PLoS Med* 2010, **7**(4):e1000231.
12. Ministry of Health V: **Introducing covid-19 diagnosis and treatment guidelines**. In., vol. 3351/QĐ-BYT Hanoi, Vietnam; 2020.
13. Ministry of Health V: **Monitoring, evaluating, and supporting the COVID-19 diagnostic**. In. Edited by Ministry of Health V, vol. 3981/BYT-DP Hanoi, Vietnam; 2020.

Tables

Table 1. Overview of risk assessment and risk management for SARS-CoV-2 testing at Hospital for Tropical Disease, Ho Chi Minh City, Vietnam.

	Pre-analytic		Analytic		Post-analytic
	Risk assessment	Risk management	Risk assessment	Risk management	Risk assessment
Engineering control	1. Clinical specimen reception: i) Exposure to biohazardous materials (inappropriately packed or leaking specimens). 2. Opening/unpacking and accessioning of sample: i) exposure to biohazardous materials (opening/unpacking of specimen carrier bags, contamination of surfaces). 3. Sample spill: 4. Unauthorized access to samples, sample loss or theft.	Dedicated sample reception room	1. Exposure during sample manipulation: 2.Exposure during vortex. 3. Sample spill in BSC 4. Exposure during TNA extraction 5. Exposure during waste disposal	Dedicated MDL for SARS Cov2 testing	1. Transcription error: 2. Noncompliance of turn time. Unauthorized access to samples. 4. Sample loss or theft.
		BSC Cl I/II for sample sorting		Safety cabinet (BSC CL I)	
		Laboratory access control		Dedicated TNA extraction system	
		Access control refrigerators		Real time PCR system	
		Dedicated waste collection bin		Access control freezers	
				Dedicated waste collection bin	
Administrative control		SOP for covid-19 sample reception		MDL operation manual	
		Laboratory safety manual		SOP for COVID-19 sample inactivation	
		Waste disposal manual		SOP RT-PCR for SARS-CoV-2	
		Spill handling procedure		Waste disposal manual	
		Hand washing SOP		Spill handling procedure	
		SOP for facility decontamination		Hand washing SOP	
				SOP for facility decontamination	
Operational control		COVID-19 sample reception training		Training on SARS-CoV-2 RT-PCR testing	
		Training on PPE use		Training on PPE donning and doffing	
		Enhanced cleaning protocol		Enhanced cleaning protocol	
		Enhanced waste disposal		Enhanced waste disposal	
		Routine inspection of the facility		Routine inspection of the facility	
		PPE Reusable lab coat		PPE (Disposable)	
		Face mask (ASTM level 2),		Face mask (N 95 or equivalent),	
		Nitrile gloves,		Nitrile gloves,	
		Lab coat,		Full sleeve lab coat (AAMI level 3)	
		Goggle		Goggle,	

	Shoe cover	Shoe cover

Table 2: Statistics of samples received, rejected, tested and turnaround time for 38,377 COVID-19 samples received from February 1 to 17th September at Hospital for Tropical Diseases, Ho Chi Minh City Vietnam.

Month	Sample received (n)	Sample rejection % (n)	Outbreak sample % (n)	Turnaround time mean ± SD day
February	115	0 (0)	0	1.3 ± 0.49
March	10833	0 (0)	70.8 (7667)	3.9 ± 1.91
April	8048	0 (0)	52.6 (4237)	2.4 ± 1.38
May	906	0 (0)	0	2.3 ± 0.88
June	529	1.2 (11)	0	2.4 ± 2.13
July	5615	1.4 (104)	93.1 (5226)	5.48 ± 3.91
August	11204	1.6 (178)	80.9 (9067)	6.2 ± 2.98
September	1127	0.2 (2)	0	2.9 ± 1.11

Figures

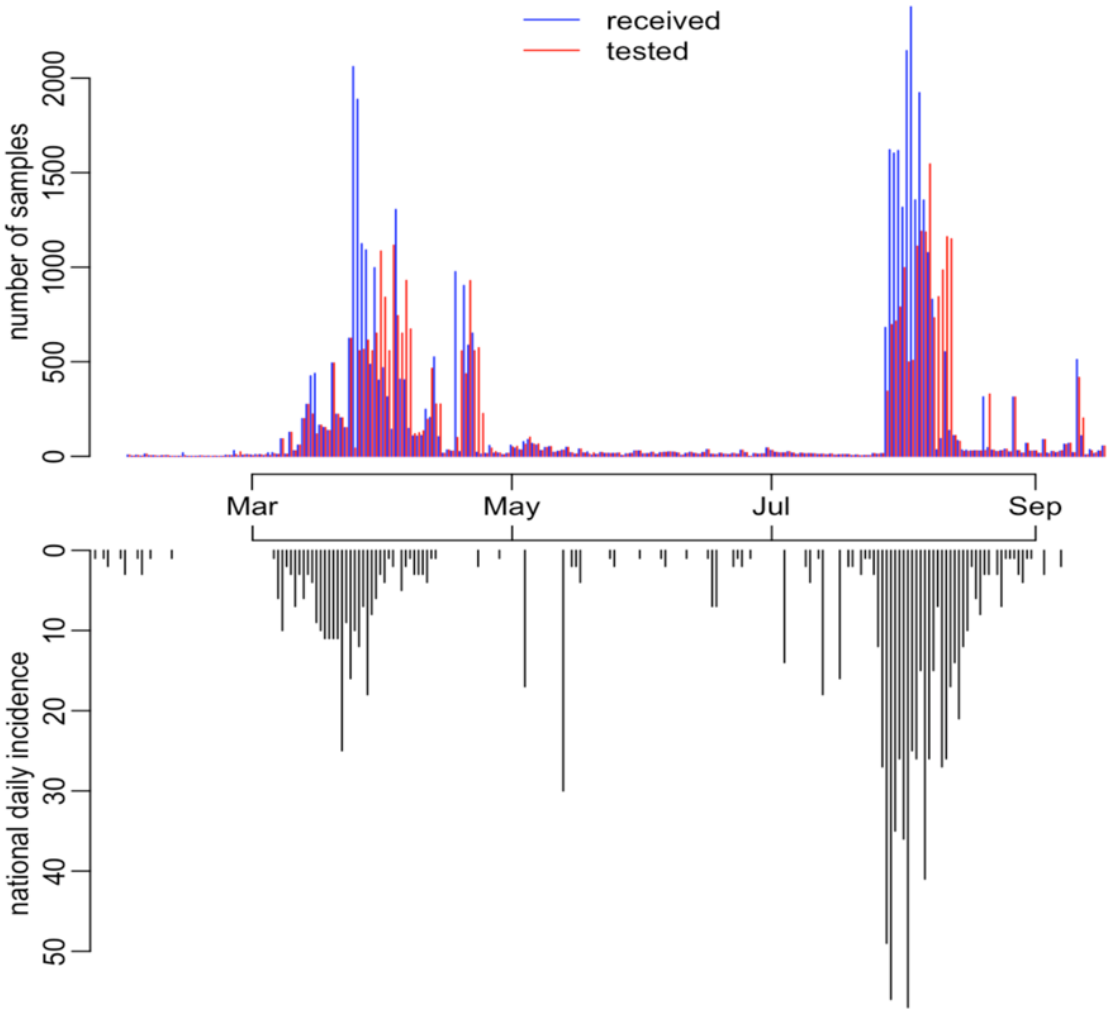

Figure 1

Number of received (blue) and tested (red) samples per day at HTD (top) and daily incidence of confirmed COVID-19 in Vietnam (bottom, reversed) over the study period.