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Applied One Health: Nigeria National Veterinary Research Institute COVID-19 pandemic response

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The COVID-19 pandemic has caused the death of 7.1 million people worldwide as of 7 July 2024. In Nigeria, the first confirmed case was reported on 27 February 2020, subsequently followed by a nationwide spread of SARS-CoV-2 with morbidity and mortality reaching 267 173 and 3155, respectively, as of 7 July 2024. At the beginning of the pandemic, only a few public health laboratories in Nigeria had the capacity for SARS-CoV-2 molecular diagnosis. The National Veterinary Research Institute (NVRI), already experienced in influenza diagnosis, responded to the public health challenge for the diagnosis of COVID-19 samples from humans. The feat was possible through the collective utilisation of NVRI human and material resources, including biosafety facilities, equipment, reagents and consumables donated by international partners and collaborators. Within 6 months of the reported COVID-19 outbreak in Nigeria, over 33 000 samples were processed in NVRI facilities covering five states. Thereafter, many field and laboratory projects were jointly implemented between NVRI and collaborating sectors including the Nigerian Centre for Disease Control (NCDC) and the National Institute for Medical Research (NIMR), which brought together professionals in the health, veterinary, education and socio-sciences. In addition, One Health grants were secured to enhance surveillance for coronavirus and other zoonoses and build capacity in genomics. Bio-surveillance for coronaviruses and other emerging zoonotic pathogens at the human–animal interface was activated and continued with sample collection and analysis in the laboratory for coronaviruses, Lassa fever virus and Mpox. One Health approach has shown that inter-sectoral and multinational collaboration for diagnosis, research and development in animals, and the environment to better understand pathogen spillover events at the human–animal interface is an important global health priority and pandemic preparedness.

Keywords: COVID-19 pandemic; SARS-CoV-2; diagnosis; NVRI; One Health.

Background

The COVID-19 pandemic, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), began in Wuhan, China in late 2019 (Phelan, Katz & Gostin 2020). As of 7 July 2024, 776 million people have been infected and 7.1 million deaths recorded worldwide (World Health Organization [WHO] 2024). In Africa, the morbidity and mortality data as of 7 July 2023 were 9.6 million/175 510, while in Nigeria, the number of deaths recorded was 3155 out of 267 173 that were infected as of 15 July 2024 (https://covid19.who.int). Nigeria reported its first confirmed case (imported) on 27 February 2020 followed by a nationwide spread of the SARS-Cov-2 that has been reported in 36 states including the Federal Capital Territory (Abuja) (Agusi et al. 2024).

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The initial challenge in the control of COVID-19 was that only a few public health and veterinary laboratories had the capacity and capabilities for SARS-CoV-2 molecular diagnosis. Thus, a One Health approach, as recommended by the WHO and WOAH (formerly OIE), provided evidence of the need for a long-standing and sustainable One Health collaboration, coordination and communication among sectors to control infectious diseases. This approach that takes cognisance of interagency capacity, capability and collaboration, was implemented in Nigeria (https://www.woah.org/en/what-we-offer/emergency-preparedness/covid-19/) during the COVID-19 pandemic management. The National Veterinary Research Institute (NVRI) already with experience in infectious disease control and diagnosis of influenza (Joannis et al. 2008) responded to the public health challenge and made its BSL-3 and BSL-2 laboratories available for diagnostic services. The BSL-3 at NVRI was built and donated to the Federal Government of Nigeria by the Canadian government before the pandemic in 2016. The facility is the hub of the safe handling of clinical samples collected from humans with suspicion of COVID-19 infection. The feat was also made possible by the collective utilisation of NVRI human and material resources including biosafety equipment, reagents and consumables provided by NVRI management and those subsequently donated by international partners and collaborators including the Africa Union, International Atomic Energy Agency (IAEA), Robert Koch Institute (RKI) and Fredrich-Loeffler-Institut (FLI). Here, we analysed and presented the outcome of multidisciplinary, multisectoral collaboration from the perspective of NVRI in a One Health approach.

Methods

The Nigeria Centre for Disease Control and Prevention (NCDC), the national public health agency, on 09 April 2020, requested the NVRI to join the SARS-CoV-2 molecular diagnostic network, which expanded to about 100 laboratories nationwide for human COVID-19 investigation and control. The threat posed by the infectiousness of the hazard made it dangerous even for laboratory personnel to handle the virus unprotected. The National Veterinary Research Institute was able to overcome this challenge through the use of its BSL-2 and BSL-3 high containment facilities. Furthermore, laboratory personnel were trained in infection prevention and control (IPC) as a preamble to handling the dangerous pathogen of the public health scare during COVID-19. As part of providing a secondary layer of protection, powered air purifying respirators (PAPR) were used. The PAPRs were provided by the United States Centre for Disease Control and Prevention (US-CDC) and previously used for Mpox animal reservoir investigation (Meseko et al. 2023). The test algorithm (Figure 1) that was also explained as part of the diagnostic refresher course for BSL-2 and BSL-3 laboratory personnel was segmented to higher and lower biological risk to reduce contamination and control of SARS-CoV-2 and other infections. High-risk activities included receiving clinical specimens and inactivation of the virus in the BSL-3 while the lower biological risk activities involved real-time quantitative polymerase chain reaction (RT-qPCR) and assay of extracted SARS-CoV-2 was carried out at the BSL-2 laboratory. This also guided the approach to testing SARS-CoV-2 in an international, interlaboratory ring trial that
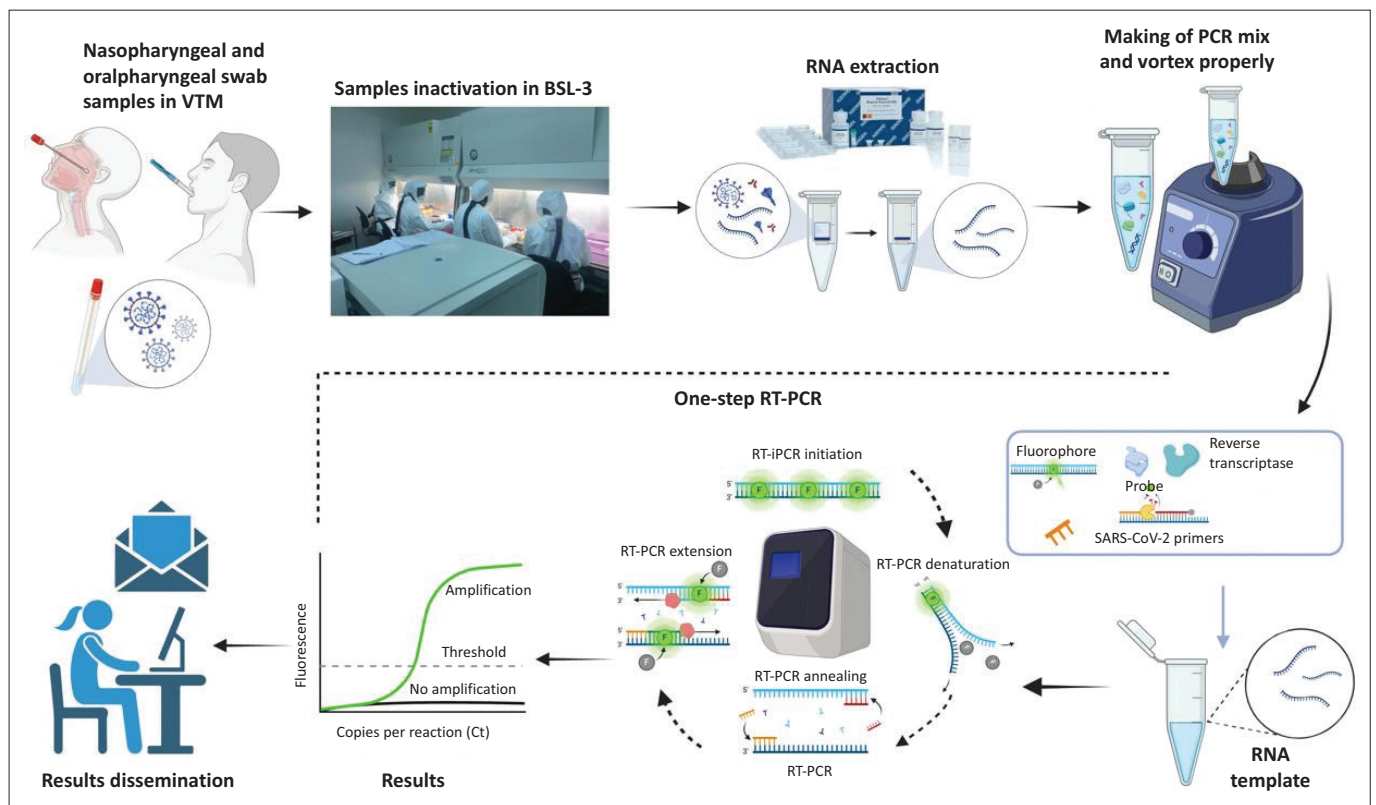
RNA, ribonucleic acid; VTM, viral transport medium; RT-PCR, real-time polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

FIGURE 1: Syndrome coronavirus 2 test algorithm in the BSL-3 and BSL-2 containment facilities at the National Veterinary Research Institute.
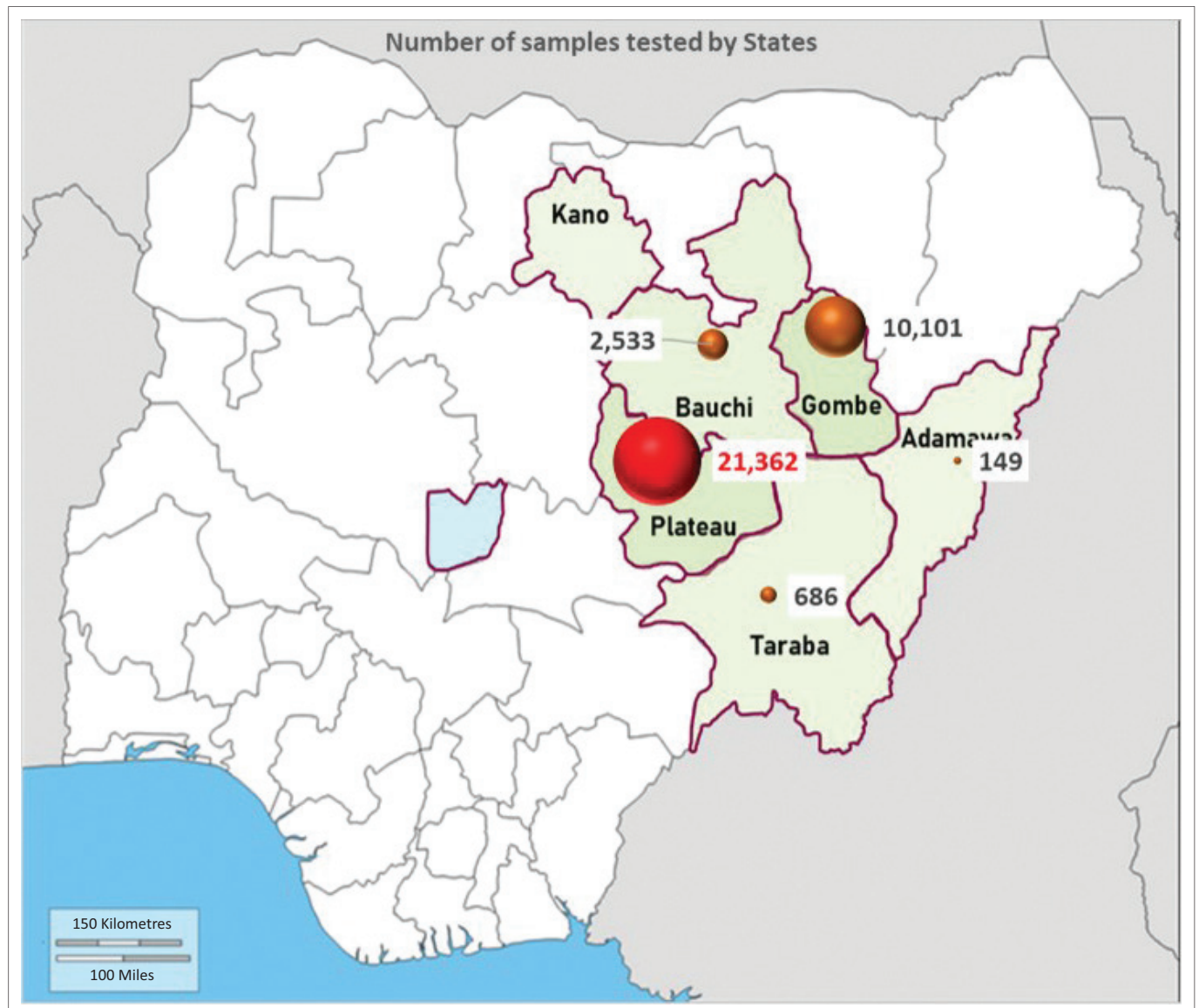
confirms the feasibility of an extraction-less 'direct' RT-qPCR method for reliable detection of SARS-CoV-2 ribonucleic acid (RNA) in clinical samples in which NVRI collaborated as a member of the network (Mills et al. 2022). Virus inactivation and RNA extraction were performed using many protocols (Table 1) depending on available reagents because of the high turnover of samples from the coverage states (Figure 2). For instance, in using DaAn gene protocols and following

TABLE 1: The different assays and protocols used for the detection and amplification of specific syndrome coronavirus 2 genes at the National Veterinary Research Institute, Nigeria during the COVID-19 pandemic.
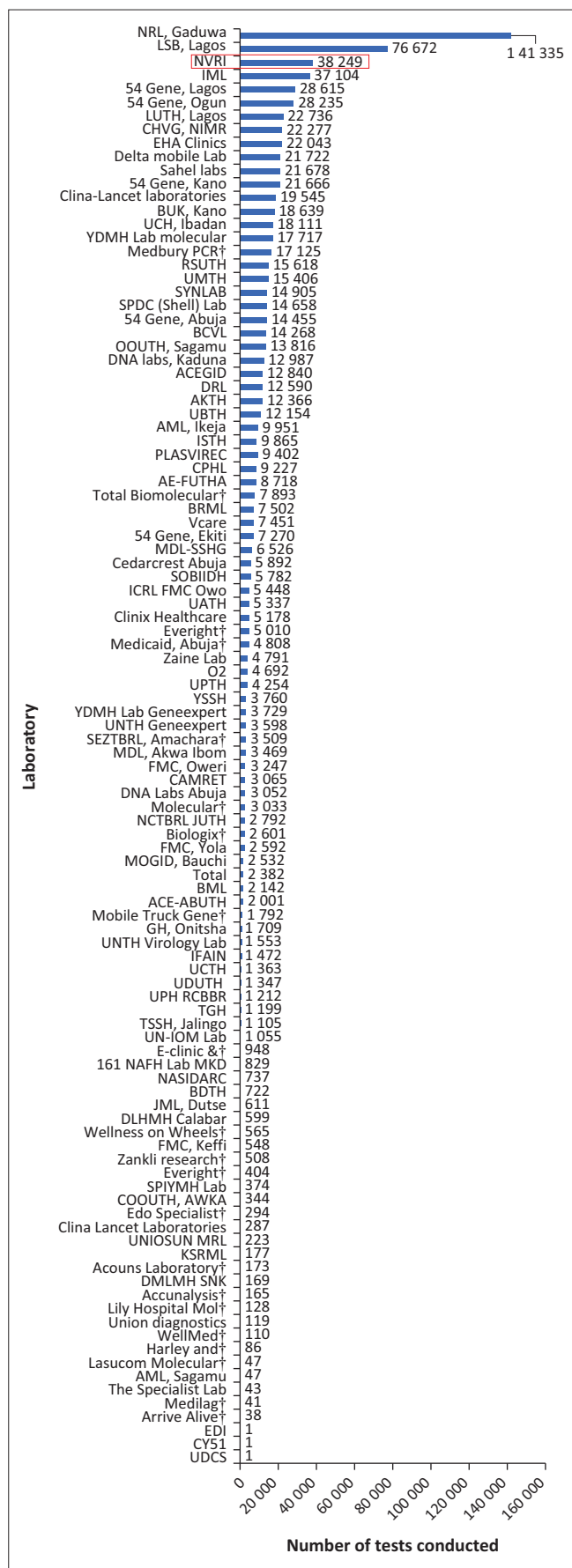
Assay/protocol	Targeted genes	Ct values (+Ve results)	References
GeneFinder	RdRp, N, and E	≤ 40	Gard et al. (2022)
Sansure	N, ORF 1 a/b	≤ 40	Wang et al. (2020), Lu et al. (2020); Hailemariam et al. (2022)
Beijing Genomic Institute	ORF 1 a/b	≤ 40	Wang et al. (2020), Van Kasteren et al. (2020); Hailemariam et al. (2022)
DaAn Gene	N, ORF1 a/b	≤ 40	Wang et al. (2021); Hailemariam et al. (2022)

Note: Please see the full reference list of the article for more information.
Ct, copies per reaction.

manufacturer's instructions (https://en.daangene.com), lysis buffer containing carrier RNA, for example, for one test = 200 µL of lysis solution was added to 4 mL of carrier RNA, for 20 test = 4 mL of the lysis solution was added to 80 mL of carrier RNA provided. An internal standard solution was briefly used to dissolve carrier RNA (dry powder) and mixed with a lysis solution. Thereafter, 200 µL of the samples were added into the 1.5 mL Eppendorf centrifuge tubes, followed by the addition of 200 µL lysis solutions containing Carrier RNA, fastening down the tube cover and vortex for 15 s then centrifuged at full speed for 10 s and then incubated at room temperature for 1 h. The inactivated samples were then sealed and transferred in the cold chain to the BSL-2 laboratory for nucleic acid extraction. The final elution of purified RNA was performed with 50 µL eluent already preheated at 72 °C. Polymerase chain reaction amplification of SARS-CoV-2 Sarbeco gene according to the manufacturer's protocols in tubes A and B was performed. Amplification result was interpreted as positive if it was less than 40 copies per reaction (Ct) values and negative when above 40 ct values.

FIGURE 2: Map of Nigeria showing number of samples tested by state for COVID-19 at the National Veterinary Research Institute, Vom.

Laboratory

Laboratory	Number of tests conducted
NRL, Gaduwa	1 41 335
LSB, Lagos	76 672
NVRI	38 249
IML	37 104
54 Gene, Lagos	28 615
54 Gene, Ogun	28 235
LUTH, Lagos	22 736
CHVG, NIMR	22 277
EHA Clinics	22 043
Delta mobile Lab	21 722
Sahel labs	21 678
54 Gene, Kano	21 666
Clina-Lancet laboratories	19 545
BUK, Kano	18 639
UCH, Ibadan	18 111
YDMH Lab molecular	17 717
Medbury PCR†	17 125
RSUTH	15 618
UMTH	15 406
SYNLAB	14 905
SPDC (Shell) Lab	14 658
54 Gene, Abuja	14 455
BCVL	14 268
OOUTH, Sagamu	13 816
DNA labs, Kaduna	12 987
ACEGID	12 840
DRL	12 590
AKTH	12 366
UBTH	12 154
AML, Ikeja	9 951
ISTH	9 865
PLASVIREC	9 402
CPHL	9 227
AE-FUTHA	8 718
Total Biomolecular†	7 893
BRML	7 502
Vcare	7 451
54 Gene, Ekiti	7 270
MDL-SSHG	6 526
Cedarcrest Abuja	5 892
SOBIIDH	5 782
ICRL FMC Owo	5 448
UATH	5 337
Clinix Healthcare	5 178
Everight†	5 010
Medicaid, Abuja†	4 808
Zaine Lab	4 791
O2	4 692
UPTH	4 254
YSSH	3 760
YDMH Lab Geneexpert	3 729
UNTH Geneexpert	3 598
SEZTBRL, Amachara†	3 509
MDL, Akwa Ibom	3 469
FMC, Oweri	3 247
CAMRET	3 065
DNA Labs Abuja	3 052
Molecular†	3 033
NCTBRL JUTH	2 792
Biologix†	2 601
FMC, Yola	2 592
MOGID, Bauchi	2 532
Total	2 382
BML	2 142
ACE-ABUTH	2 001
Mobile Truck Gene†	1 792
GH, Onitsha	1 709
UNTH Virology Lab	1 553
IFAIN	1 472
UCTH	1 363
UDUTH	1 347
UPH RCBBR	1 212
TGH	1 199
TSSH, Jalingo	1 105
UN-IOM Lab	1 055
E-clinic &†	948
161 NAFH Lab MKD	829
NASIDARC	737
BDTH	722
JML, Dutse	611
DLHMH Calabar	599
Wellness on Wheels†	565
FMC, Keffi	548
Zankli research†	508
Everight†	404
SPIYMH Lab	374
COOUTH, AWKA	344
Edo Specialist†	294
Clina Lancet Laboratories	287
UNIOSUN MRL	223
KSRML	177
Acouns Laboratory†	173
DMLMH SNK	169
Accunalysis†	165
Lily Hospital Mol†	128
Union diagnostics	119
WellMed†	110
Harley and†	86
Lasucom Molecular†	47
AML, Sagamu	47
The Specialist Lab	43
Medilag†	41
Arrive Alive†	38
EDI	1
CY51	1
UDCS	1

Number of tests conducted (0, 20 000, 40 000, 60 000, 80 000, 100 000, 120 000, 140 000, 160 000)

Source: Nigeria Center for Disease Control and Prevention, Federal Ministry of Health and Socio Welfare, Federal Ministry of Health, Nigeria, viewed 20 December 2020, from https://ncdc.gov.ng

Abbreviations: ACEGID, African Centre of Excellence for Infectious Disease; DRL, Defence Reference Lab; AKTH, Amino Kano Teaching Hospital; UBTH, University of Benin Teaching Hospital; AML, Ikeja, Advanced Molecular Laboratory, Ikeja; ISTH, Irrua Specialist Teaching Hospital; PLASVIREC, Plateau State Human Virology Research Center, Laboratory; CPHL, Central Public Health Laboratory; AE-FUTHA, Alex Ekwueme Federal University Teaching Hospital, Abakaliki; BRML, Bauchi Reference Molecular Laboratory; MDL-SSHG, Molecular Diagnostics Laboratory-State Specialist Hospital Gombe; Cedarcrest Abuja, Cedarcrest Hospital Molecular Laboratory; SOBIIDH, Sobi Infectious Disease Hospital, Kwara; ICRL FMC Owo, Infectious Diseases Control and Research Laboratory, Federal Medical Center, Owo; UATH, University of Abuja Teaching Hospital; Zaine Lab, Reddington Zaine Laboratory and Armoured Shield Medical Center; O2, 02; UPTH, University of Portharcourt Teaching Hospital; YSSH, Yobe State Specialist Hospital, Damaturu; YDMH Lab Gene expert, Yobe State Specialist Hospital, Damaturu; UNTH Gene expert, University of Nigeria Teaching Hospital, Gene expert; MDL, Akwa Ibom, Molecular Diagnostic Laboratory, Akwa Ibom; FMC Oweri, Federal Medical Center, Oweri; CAMRET, Centre for Advancement Medical Research and Training, Usman Dan Fodiyo University Hospital; DNA Labs Abuja, Deoxyribose Nucleic Acid Laboratories, Abuja; NCTBRL JUTH, North-Central Tuberculosis Research Laboratory-Jos University Teaching Hospital; FMC, Yola, Federal Medical Center, Yola; MOGID, Bauchi, Molecular Genetics and Infectious Disease Laboratory, Bauchi; BML, Bayero University Medical Laboratory; ACE-ABUTH, Ahmadu Bello University Teaching Hospital; GH, Onitsha, General Hopsital, Onitsha Laboratory; UNTH Virology Lab, University of Nigeria Teaching Hospital Virology Laboratory; IFAIN, International Foundation Against Infectious Disease in Nigeria; UCTH, University of Calabar Teaching Hospital; UDUTH, Usman Danfodio University Teaching Hospital; UPH RCBBR, University of Portharcourt Regional Center for Biotechnology; TGH, Takum General Hospital; TSSH, Jalingo, Taraba State Specialist Hospital; UN-IOM Lab, United Nations-International Organization for Migration Laboratory; 161 NAFH Lab MKD, 161 Nigeria Airforce Hospital Makurdi; NASIDARC, Nasarawa State Infectious Diseases and Research Centre; BDTH, Barau Dikko Teaching Hospital; JML, Dutse, Jigawa Molecular Laboratory; DLHMH Calabar, Dr. Lawrence Henshaw Memorial Hospital (IDH) Calabar; FMC, Keffi, Federal Medical Center, Keffi; SPIYMH Lab, Sir Patrick Ibrahim Yakowa Memorial Hospital laboratories; COOUTH, Awka, Chukwuemeka Odumegwu Ojukwu University Teaching Hospital, Amaku, Awka; UNIOSUN MRL, Osun State University, Multidisciplinary Research Laboratory; KSRML, Kogi State Reference Molecular Laboratory; DMLMH SNK, Molecular Diagnostics Laboratory-State Specialist Hospital Gombe; AML, Sagamu, Advanced Molecular Laboratory, Sagamu; EDI, Edo State Diagnostic Institute; CY51, Wavelength for qPCR excitation; UDCS, University of Benin Diagnostic Center Service; Lab, laboratory.

†, Medbury PCR, Medbury Services Limited, Polymerase Chain Reaction Laboratory; Total Biomolecular, Total Biomolecular Laboratory, Lagos; Vcare, Vcare Diagnostics Limited, Lagos; Clinix Healthcare, Clinix Healthcare Laboratory, Lagos; Everight, Everight Diagnostics Laboratory Abuja; Medicaid, Abuja, Medicaid Radio-diagnostics & Clinics, Abuja; SEZTBRL Amachara, TB Reference Laboratory, SEZTBRL, Amachara, Abia State; Molecular, Molecular Laboratory, Akwa Ibom; Biologix, Biologix Laboratories, Abuja; Mobile Truck Gene, Mobile Truck Gene Expert Laboratory, Kano; E-clinic &, E-clinic and Diagnostics, Abuja; Wellness on Wheels, Wellness on Wheels-detecting TB Lab, Nigeria; Zankli Research, Zankli Research Center; Everight, Everight Diagnostic & Laboratory Services Ltd; Edo Specialist, Edo Specialist Hospital; Clina-Lancet, Clina Lancet Laboratories; Acouns Laboratory, Acouns Laboratory and Diagnostic Centre; Accunalysis, Analysis Diagnostic Centre; Lily Hospital Mol, Lily Hospital Molecular Laboratory; WellMed, WellMed Healthcare Limited; Harley and, Harley and Rainbow Specialized Laboratory; Lasucom Molecular, Lagos State University College of Medicine; Medilag, Medilag Consults, Unversity of Lagos; Arrive Alive, Arrive Alive Diagnostics and Image services.

FIGURE 3: National Veterinary Research Institute (in red) tests of COVID-19 pandemic samples.

Results and discussion

Fifty-five thousand human samples were processed by the NVRI between May 2020 and December 2021 out of which 2345 (4.26%) were tested positive by RT-qPCR. In the first 6 months, over 33 000 samples were processed and NVRI performed 10% of the total samples collected ranking 3rd out of 100 laboratories in output by December 2020 (Figure 3). This was possible by the collective utilisation of NVRI human and material resources including a BSL-2 and BSL-3 laboratories. Personal protective equipment, reagents and consumables support came from internal resources at NVRI, and additional support from NCDC, RKI/FLI (Germany), IAEA and AU among others. Many field and laboratory projects were jointly implemented between NVRI and NCDC including knowledge-sharing platforms such as the Nigeria COVID-19 Research Coalition (NCRC) (https://von.gov.ng/tag/the-nigeria-covid-19-research-coalition/). This brought together professionals in the health, veterinary, education and socio-sciences. The Nigeria addressing COVID-19 through One Health (NACOH) research grant was awarded by the Global Health Protection Programme (GHPP) of the German government to build capacity in genomics and achieve the first strands of SARS-CoV-2 sequences at NVRI, Vom (https://ghpp.de/fileadmin/images/ueber-das-ghp/Datasheet_2021/Datasheet_21_CoGLo/NACOH_CGP.pdf).

The National Veterinary Research Institute researchers were actively engaged in incidence control both at the national and state levels and participated in case identification, tracing and sample collection. Collaborations in research are evidenced by a number of publications including the explorative development of antivirals based on Nigerian medicinal plants (Falang et al. 2020; Kabantiyok et al. 2022; Meseko, Shittu & Adedeji 2020).

Enhanced capacity for biosurveillance for coronaviruses and other emerging zoonotic pathogens at the human–animal interface and socio-anthropogenic information were highlighted (Agusi et al. 2024). The NVRI Staff were also actively involved in research communication as evidenced by many other published articles (Agusi et al. 2023, 2024; Forcados et al. 2021; Mills et al. 2022). Nigeria had experienced pandemics before COVID-19 including the Influenza Pandemic of 1918 and Pandemic H1N1 (swine flu) of 2009 (Itodo 2023; Meseko et al. 2019) but none of the previous pandemics had as much impact on the health, economy, livelihood and socio welfare of the people. While pandemics are not predictable, the importance of improving measures for early detection, prevention and mitigation cannot be overemphasised. In Africa generally and Nigeria in particular, the main lessons learnt in the aftermath of the COVID-19 pandemic is the imperative of developing and enhancing in-country capacity for laboratory diagnosis, early detection, reporting and control of the spread of infectious diseases such as SARS-CoV-2. With respect to infectious disease diagnosis, COVID-19 showed similarity and leverage in human and animal health sectors. Mutually beneficial cooperation and collaboration in the sense of the One Health approach and mapping capacity and capability of laboratories in the network can impact disease control. The infectious diseases diagnostic network that was facilitated during the COVID-19 pandemic has the added benefit of improving the diagnostic capacity in Nigeria for many other infections as many molecular diagnostic services are closer to sub-national levels thus improving turn-around time for diagnostic results. Many of these networks of diagnostic laboratories are functional and have expanded beyond clinical diagnosis to include research. Consortium for genomic surveillance, bio-repository and attracting grants for sustainability post-COVID-19 pandemic is a priority within the molecular diagnostic network and is an important contribution to nation-building.

Conclusion

The importance of One Health collaboration in diagnostics and research in humans and animals in a shared environment cannot be overemphasised. The COVID-19 pandemic provided the opportunity to move from theory to the practice that a long-standing and sustainable One Health collaboration is needed for infectious disease control.

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Competing interests

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Authors' contributions

C.A.M., I.S., O.O.A., A.J.A. and B.J.A. contributed to the conception, lab analysis, writing of the original draft and editing. T.A.L., E.R.A., D.A.G., K.A.O., N.M., C.C., B.I., N.C., R.A., P.N., H.L., J.B., R.A., D.K., M.S., T.D., J.O. and E.T.O. contributed to the lab analysis and editing. O.A.O., R.A.O. and M.M. contributed to the conception and editing. D.D.L. contributed to the lab analysis, writing the original draft and editing. P.D.L., S.M., H.H.U., Y.S.W. and J.S.A. contributed to the conception, lab analysis and editing.

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Data availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

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