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# Virtual system for early detection of COVID-19 infection "Etaware-CDT-2020 prototype design" (corroborated by rRT-PCR data)

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ABSTRACT

The 2nd phase of COVID-19 infection outbreak experienced worldwide is an attestation to the decline in the efficiency of COVID-19 detection kits available worldwide. rRT-PCR still remains the best confirmatory test for COVID-19 infection. Sadly, most medical professionals are not conversant with the rRT-PCR protocols. Therefore, more easy-to-use alternatives are required as backup, to compensate for these lapses. "Etaware-CDT-2020" is a virtual system designed for early detection of COVID-19 infection. A comparative COVID-19 diagnosis was conducted using Etaware-CDT-2020, corroborated by rRT-PCR-confirmed COVID-19 results obtained from China (Latitude 35.8617$^{o}$N and Longitude 104.1954$^{o}$E), which was the epicentre for COVID-19 infection outbreak. A cross-comparison of results showed that there was a positive correlation between the output result from Etaware-CDT-2020 and rRT-PCR diagnosis from Wuhan ($r = 0.92$) and Hubei ($r = 0.97$). Furthermore, there was no significant difference between the diagnostic results of "Etaware-CDT-2020" and rRT-PCR, when compared by T-test ($P(t = 0) > 0.05$) and Pearson's Chi-Square test ($0.04 \geq P \leq 0.12$). Etaware-CDT-2020 is unique and can be used anywhere, anytime and by anyone. It is accessible, affordable, easy to install, simple to understand and user friendly.

## 1. Introduction

The novel and deadly Coronavirus disease 2019 (COVID-19), caused by the noxious pathogen "Sars-Cov-2", is a serious threat to global health, due to its ability to mutate and adapt to different hosts (intermediate, collateral, alternate or primary), their environment and body system [8], combined with the ability to subdue or bypass the complex network of human immune system or defense mechanism(s) [9], resulting in a fleet of new waves of COVID-19 infection around the world [14]. In response to the global insecurity of human lives to infectious diseases [30], some manufacturers developed easy-to-use rapid immunodiagnostic test (IRT) kits for use in clinics, hospitals and isolation centres [31]. Sadly, some of these RIT kits have major defects i.e., their functionality and efficiency were largely affected by the amount and quality of viral protein (Antigens) and antibodies present in respiratory, blood and serum samples of infected patients and those with latent infection [21,27,36].

Clinical diagnosis of COVID-19 infection using rRT-PCR is still the most effective and accurate means of confirming cases of COVID-19 infections all around the world [10,11]. Unfortunately, the knowledge and application of the most recent rRT-PCR protocols, the management of infected samples, and the operation of the rRT-PCR machine by some medical staff is below average, coupled with the unavailability of BSL-2 facilities in developing and underdeveloped countries of the world. These are some of the major reasons behind the geometric increase in the circulation of "false-positive" COVID-19 results in Africa and some Countries/States in America, Antarctica, Asia, Australia, and Europe, where these medical lapses are highly pronounced. The rising occurrence of COVID-19 infection among medical personnel and most health care providers around the globe, is also a major cause for concern. The involvement of more COVID-19 tests (screening, or detection and confirmatory tests) in countries where rRT-PCR is not readily available is highly recommended. Therefore, this research seeks to juxtapose the results of COVID-19 infection diagnosis in China, confirmed by rRT-PCR, with the diagnosis performed on the same patients using Etaware-CDT-2020, in order to provide a reliable platform for screening and early detection of COVID-19 infection, prior to confirmation by rRT-PCR. Finally, a plethora of all possible techniques for the diagnosis of COVID-19 infection, can help minimize "false-positive" diagnosis, detect slightest aberration in the disease phenology and further avert the

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outbreak of new waves of deadly COVID-19 infection outbreak around the world.

### 1.1. Hypothesis

**Hypothesis (Null)**: There are no underlying medical or clinical differences existing between the COVID-19 symptoms used as adoptive markers in the programming of "Etaware-CDT-2020" and COVID-19 infection diagnosis in humans.

**$Ho_1$**: $\beta_1 = \beta_2 = \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\beta_{26} = 0$

**Hypothesis (Alternative)**: There are underlying medical or clinical differences existing between the symptoms or adoptive markers selected for the programming of Etaware-CDT-2020 and COVID-19 infection diagnosis in humans.

**$Ha_1$**: $\beta_1 \neq 0$ or $\beta_2 \neq 0$ $\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$or $\beta_{26} \neq 0$

### 1.2. Research assumptions

1. The symptoms used as adoptive markers for this research have been certified by World Health Organization (WHO). They are indeed associated with coronavirus disease 2019 irrespective of the geographical location of the host(s), the time of infection, and the region affected by the disease outbreak.
2. All humans are susceptible to the disease regardless of the race or tribe of the host(s), or the gender of the individual(s).
3. The symptoms used for the programming of "Etaware-CDT-2020" are not evasive or different from patient to patient (i.e., they are ubiquitous or universal marker of the disease).
4. Etaware-CDT-2020 is as reliable as the quality of information used in its programming.
5. Modifications made by the author for effective quantification of COVID-19 infection were cross-checked to correspond with the current medical ethics. These modifications were indeed intuitively borne out of rational reasoning, creative thinking and logical evaluations.

## 2. Methodology

### 2.1. Symptoms characterization

The symptoms associated with COVID-19 infection, as described by WHO, were classified into three (3) major "adoptive" markers based on the degree of relatedness with the disease (Table 1). System upgrade and program flexibility were put into consideration to allow flawless incorporation of new symptoms without diminishing its quality. The COVID-19 infection levels pertinent for efficient diagnosis (as described by this study) were listed in Table 2.

### 2.2. The coronavirus disease 2019 diagnostic model

The novel prototype system for early detection of COVID-19 infection was developed by Etaware [11]. The primary data used for structuring the model was described (in brief) in section 3.2

### 2.3. Case study for complementary COVID-19 diagnosis

The major focus of this research was China, because it was the origin of the deadly COVID-19 infection. China is located on Latitude 35.8617°N and Longitude 104.1954°E in the continent of Asia. The country is bounded in the east by the East China- and Yellow Seas, in the west by Afghanistan, Tajikistan, Kyrgyzstan, and Kazakhstan, in the north by Mongolia, Russia, and North Korea, and in the south by

**Table 1**
WHO classification of symptoms associated with COVID-19 infection.

| Categories | Code | Adoptive Markers (AM) | Related illness | Comp. Score | Inference |
|---|---|---|---|---|---|
| Prominent Symptoms | $AM_1$ | Fever | Malaria, Typhoid etc. | 0.20 | Necessary |
| | $AM_2$ | Fatigue (Tiredness) | | 0.20 | Necessary |
| | $AM_3$ | Dry/Chesty Cough | Respiratory illness | 0.20 | Necessary |
| General Symptoms | $AM_4$ | Muscular aches and pains (Myalgia) | Fever | 0.02 | Optional |
| | $AM_5$ | Chill/Shivering | | 0.02 | Optional |
| | $AM_6$ | Headache | | 0.02 | Optional |
| | $AM_7$ | Loss of appetite | | 0.02 | Optional |
| | $AM_8$ | Shortness of breath (Dyspnoea) | Respiratory illness | 0.02 | Optional |
| | $AM_9$ | Sore throat | | 0.02 | Optional |
| | $AM_{10}$ | Loss of sense of smell | | 0.02 | Optional |
| | $AM_{11}$ | Loss of sense of taste | | 0.02 | Optional |
| | $AM_{12}$ | Nasal congestion | | 0.02 | Optional |
| | $AM_{13}$ | Chest pain | | 0.02 | Optional |
| | $AM_{14}$ | Abdominal pain | Gastrointestinal illness | 0.02 | Optional |
| | $AM_{15}$ | Diarrhoea | | 0.02 | Optional |
| | $AM_{16}$ | Vomiting or Nausea | | 0.02 | Optional |
| | $AM_{17}$ | Neurological illness | Neurological illness | 0.02 | Optional |
| | $AM_{18}$ | Gastrointestinal illness | Gastrointestinal illness | 0.02 | Optional |
| | $AM_{19}$ | Drowsiness | Neurological illness | 0.02 | Optional |
| | $AM_{20}$ | Dizziness | | 0.02 | Optional |
| Specific Symptoms | $AM_{21}$ | Stroke | Neurological illness | 0.01 | Optional |
| | $AM_{22}$ | Pneumonia | Respiratory illness | 0.01 | Optional |
| | $AM_{23}$ | High body temperature | Fever, Malaria, Typhoid etc. | 0.01 | Optional |
| | $AM_{24}$ | Rhinorrhoea (Runny nose) | Respiratory illness (Children) | 0.01 | Optional |
| | $AM_{25}$ | Body rash | Dermatological illness | 0.01 | Optional |
| | $AM_{26}$ | Conjunctivitis | | 0.01 | Optional |
| **Total** | **P = 26** | **26 Predictors** | | **1.00** | |

**Source**: [5,6,8,15,16,17,18,20,23,27,34]. The following should be Noted:
1. The complementary score (Comp. Score) was pre-defined by the author [11].
2. It has no medical or statistical relationship with the symptoms itemized.
3. It is just a guide used by the author to quantify the importance of each symptom to COVID-19 infection, in order to generate a rationale system for screening COVID-19 infections in humans

**Table 2**
The suspect-case definition for coronavirus disease 2019 (COVID-19) Diagnosis.

| COVID-19 Infection Status | | | | | Etaware-CDT-2020 Diagnosis/inference | | | |
|---|---|---|---|---|---|---|---|---|
| Stage | $Y_{sars\text{-}cov\text{-}2}$ (%) | $\hat{Y}_{sars\text{-}cov\text{-}2}$ (%) | Infected | Medical Condition | Disease Status | RD | DD | Action Required |
| $L_{10}$ | 90–100 | 95.0 | Yes | Death | Extremely Severe | Yes | Yes | Mortuary/Cemetery |
| $L_{09}$ | 80–89 | 84.5 | Yes | ICU | Severe | Yes | Yes | Hospital Admission |
| $L_{08}$ | 70–79 | 74.5 | Yes | MV/OM/MOD/Unconscious/IV | " | Yes | Yes | Hospital Admission |
| $L_{07}$ | 60–69 | 64.5 | Yes | ARD/Critical/Fatal | " | Yes | Yes | Hospital Admission |
| $L_{06}$ | 50–59 | 54.5 | Yes | Infected (Severe) | Mildly Severe | Yes | Yes | Hospital Admission |
| $L_{05}$ | 40–49 | 44.5 | Yes | Infected (Stable Conditions)/SARS /MERS/RD | " | Yes | Yes/No | Quarantine |
| $L_{04}$ | 30–39 | 34.5 | Yes/No | RD/Early signs of Infection | Early Infection | Yes | Yes/No | Quarantine/Isolation |
| $L_{03}$ | 20–29 | 24.5 | Yes/No | RD | Suspected case | Yes | Yes/No | Self-Isolation |
| $L_{02}$ | 10–19 | 14.5 | Yes/No | Mild RD/Asymptomatic Patients | " | Yes/No | Yes/No | Medical Attention |
| $L_{01}$ | 01–09 | 5.00 | Yes/No | DD/Asymptomatic Patients | " | Yes/No | Yes/No | Clinical Observation |
| $L_{00}$ | Below 1 | 0.50 | No | Discharged/Healthy | Healthy | No | No | None |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, OM → Oxygen Mask, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, SARS → Severe Acute Respiratory Syndrome, MERS → Middle East Respiratory Syndrome, RD → Respiratory Distress, DD → Digestive Disorder, IV → Invasive Ventilation, $Y_{\mathbf{sars\text{-}cov\text{-}2}}$ → COVID-19 Infection, SCD-B → Suspect Case Definition Boundary for COVID-19 infection, $\hat{Y}_{\mathbf{sars\text{-}cov\text{-}2}}$ → Class Midpoint/Mean value of COVID-19 infection calculated from the SCD-B value.
**Note**: The levels for COVID-19 infection ($Y_{sars\text{-}cov\text{-}2}$) was carefully defined by P. M. Etaware © 2020, in line with the corresponding medical condition(s), to aid effective quantification and possible categorization of all COVID-19 cases.

Vietnam, Laos, Myanmar (Burma), India, Bhutan, Nepal, Pakistan, and The South China Sea. The altitude of China is 13,000 feet (in the east) and 16,500 feet (in the west) above sea level [13], with an annual precipitation of 685 mm and an all-time lowest temperature of −40 °C [7]. There are 34 districts and 23 provinces in China, with a population of 1,404,070,000 individuals, a population density of 147 persons per Sq Km (as at 2020), and a landmass of 9,572,900 Sq Km [13].

### 2.4. rRT-PCR data source

The data used for this study were actual COVID-19 diagnosis of Chinese patients, aided by rRT-PCR. The information acquired comprised of medical records of admitted or hospitalized patients from the epicentre of COVID-19 outbreak i.e., 41 Patients from the provincial capital "Wuhan" [18], 204 Patients from Hubei Province [27], 1099 patients from 552 hospitals in China [15], and a gross total of 46,959 Patients from China [4].

### 2.5. Test statistics

The data obtained were mined and cleansed in order to annihilate misrepresented values, outliers and ambiguous datasets. Minitab 16.0 and SPSS 20.0 software were used for data analysis. The predictors were tested against the desired response variables using Pearson's Product Moment of Correlation (r). The proportion of variance in the response (dependent) variable was determined by the coefficient of determination ($R^2$) of the regression model, while the measure of multicollinearity among the predictors (independent variables) was measured by the variance inflation factor (VIF) and tolerance limit (T). The model statistics was described using the coefficient of correlation (R), coefficient of determination ($R^2$), adjusted value for the coefficient of determination (Adj. $R^2$) and a standardized predicted coefficient of determination value (Pred. $R^2$) calculated for the regression model. The test statistics used in discerning the relatedness of the estimated (computer simulated values) and actual (rRT-PCR) COVID-19 infection diagnosis result was the correlated T-test (COSTAT 6.451 Statistical software) and Pearson's Chi-Square ($\chi^2$) at $P < 0.05$. Graphs and figures were generated from Microsoft Office (2016), Minitab 16.0 and SPSS 20.0 software.

Mathematically, the midpoint ($\hat{Y}_{sars\text{-}cov\text{-}2}$) for each COVID-19 infection level was calculated thus:

$$\text{Midpoint} = \frac{Upper[SCD - Boundary] - Lower[SCD - Boundary]}{2}$$

$$Å¶sars - cov - 2 = \frac{U_{SCD-Boundary} - L_{SCD-Boundary}}{2}$$

## 3. Results

### 3.1. Input device for the computer program "Etaware-CDT-2020"

The input device shown in Fig. 1 was designed using an exhaustive list of all identified symptoms of COVID-19 infection affirmed by WHO and coded in the present study as "Adoptive Markers" (as at May 2020). The primary function of the input device was to collect and store information from prospective patients, and also, to act as a mediating platform between information collected and those analysed i.e., It will serve as a basic guide for prospective patients and a feed-in device for the novel prototype design "Etaware Computer Diagnostic Tool-2020" (or Etaware-CDT-2020). The information on the input device include:

- The patient's identity
- Already established COVID-19 symptoms (In categories)
- The assessment columns

The coding of information from the input device to the prototype system is done by converting clinical facts to figures i.e., every clinical symptom(s) of COVID-19 infection marked under the "YES" column should be coded as "1", while those marked under the "NO" column should be coded as "0", those marked under the "UNSURE" column will be automatically coded as "0" by the prototype system.

### 3.2. Summary of pry data used for modelling "Etaware-CDT-2020"

The medical records of 4,856 virtual patients were used as primary data for the present study. A total of 57.5% of the patients assessed had fever, 56.7% had dry or chesty cough and 52.5% experienced fatigue (Table 3), these were the most prominent markers or indicators of the disease. A total of 50.8% of the patients' population experienced Shortness of breath (Dyspnoea) and Muscular aches and Pains (Myalgia), while 54.2% had the chills. Sore throat was common in 51.7% of the patients' population, while other symptoms recorded were within the range of 21–55% of the population of patients under medical observation (Table 3). A total of 10.83% of the patients were either confirmed dead or in ICU or were suspected to be infected by the disease or just merely having digestive disorders (Table 4). One-eighth (12.5%) of the total population were suffering from acute respiratory diseases, whereas, 8.33% of the patients infected with the disease were either

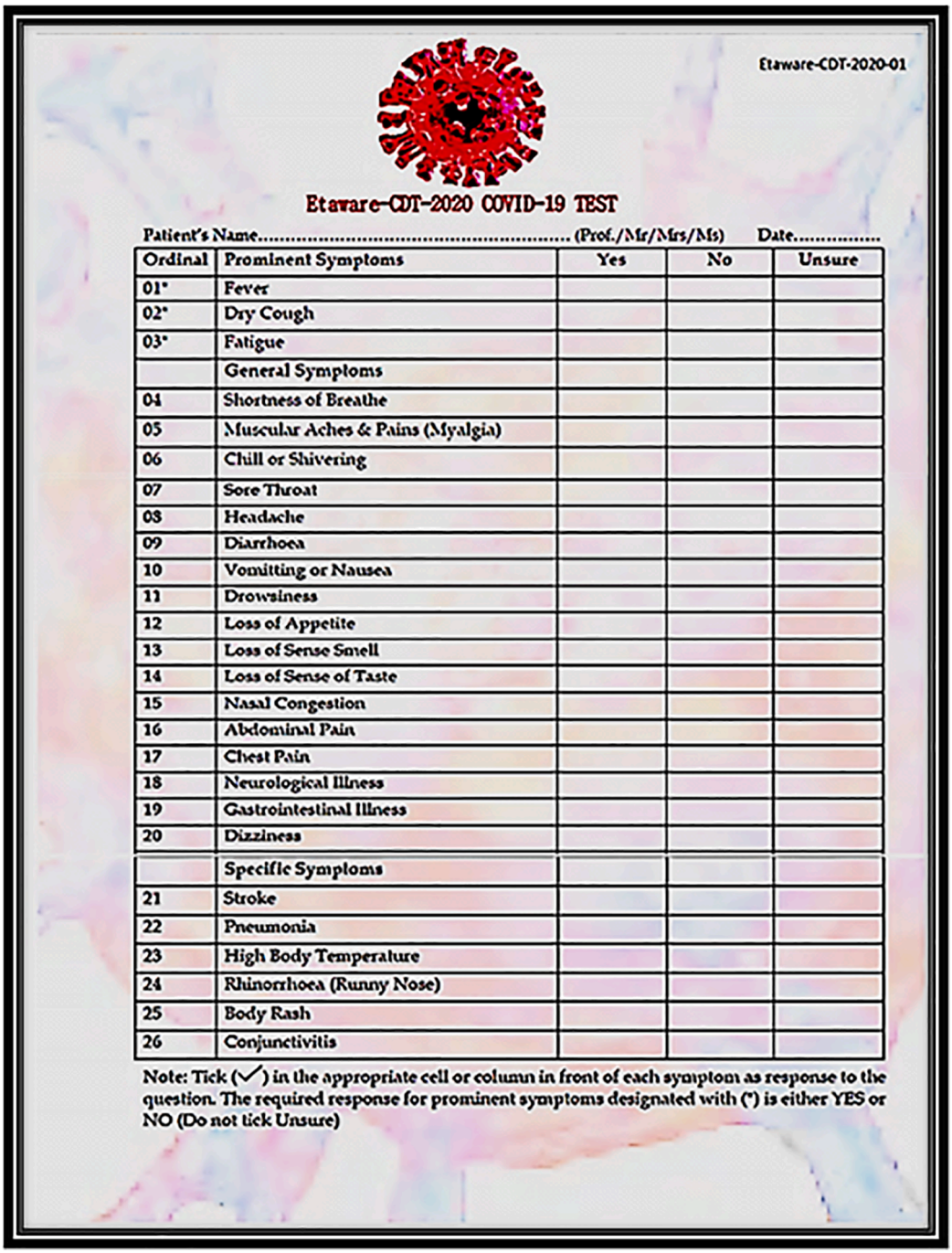


**Fig. 1.** The input device for the computer program "Etaware-CDT-2020".

confined to the use of mechanized oxygen dispensers or still under conditions of self-sustenance (Table 4).

### 3.3. Summary of rRT-PCR data obtained from China

The outbreak of fever among COVID-19 patients was well pronounced in all the districts and provinces of China i.e., 100% occurrence was recorded in Hubei Province (90% in the capital "Wuhan"), 88.7% scattered across 552 hospitals in 30 districts within China, and 87.3% of COVID-19 patients from the 34 districts and 23 provinces of China (Table 5). There was no comprehensive report of dry or chesty cough among COVID-19 patients in Hubei Province but 80% of patients with this symptom was reported in the provincial capital "Wuhan". The total population of COVID-19 patients with dry cough symptoms across the 23 provinces of China was reported as 58.1% (67.8% from 30 out of the 34 districts investigated). Patients with severe gastrointestinal disorders were predominant in Hubei and other parts of China (<40%), while those with severe respiratory distress symptoms were common in China as a whole (<35%) as shown in Table 5.

### 3.4. The computer program "Etaware-CDT-2020"

Etaware-CDT-2020 was modelled using virtual data for healthy, unhealthy (patients infected with other ailments related to COVID-19 infection), and COVID-19 infected patients (see details of model development in Etaware [11]). The model was fitted using the multiple

**Table 3**
Medical Records of 4,856 virtual COVID-19 Patients from China.

| Symptoms | Case (%) | Population (N) | Sample (n) |
|---|---|---|---|
| Fever | 57.5 | 2,792 | 69 |
| Dry Cough | 56.7 | 2,753 | 68 |
| Fatigue | 52.5 | 2,549 | 63 |
| Shortness of Breath | 50.8 | 2,467 | 61 |
| Myalgia | 50.8 | 2,467 | 61 |
| Shivering | 54.2 | 2,632 | 65 |
| Sore Throat | 51.7 | 2,511 | 62 |
| Headache | 52.5 | 2,549 | 63 |
| Diarrhoea | 45.0 | 2,185 | 54 |
| Nausea | 43.3 | 2,103 | 52 |
| Drowsiness | 39.2 | 1,904 | 47 |
| Loss of Appetite | 37.5 | 1,821 | 45 |
| Loss of Sense of Smell | 35.8 | 1,738 | 43 |
| Loss of Sense of Taste | 36.7 | 1,782 | 44 |
| Nasal Congestion | 37.5 | 1,821 | 45 |
| Stroke | 23.3 | 1,131 | 28 |
| Pneumonia | 26.7 | 1,297 | 32 |
| Abdominal Pain | 31.7 | 1,539 | 38 |
| Chest Pain | 33.3 | 1,617 | 40 |
| Neurological Ailment | 34.2 | 1,661 | 41 |
| Gastrointestinal Ailment | 33.3 | 1,617 | 40 |
| Dizziness | 33.3 | 1,617 | 40 |
| High Body Temperature | 21.7 | 1,054 | 26 |
| Rhinorrhoea | 23.3 | 1,131 | 28 |
| Rash | 29.2 | 1,418 | 35 |
| Conjunctivitis | 54.2 | 2,632 | 65 |
| **Total no. of patients** | | **4,856 Patients** | **120 Patients** |

The data for the virtual samples (120 patients) used for this experiment are available in Supplementary File "S1".

regression equation:

$$Y_{sars\text{-}cov\text{-}2} = -\alpha_{sars\text{-}cov\text{-}2} + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \ldots\ldots + \beta_{26}X_{26} + \xi_{sars\text{-}cov\text{-}2}$$

$$Y_{sars-cov-2} = -\alpha_{sars-cov-2} + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \ldots\ldots + \beta_{26}X_{26} + \xi_{sars-cov-2}$$

where $Y_{sars\text{-}cov\text{-}2}$ = COVID-19 Infection status (Response variable)

$X_1 \rightarrow X_{26}$ = COVID-19 general symptoms (Predictors)
$\beta_1 \rightarrow \beta_{26}$ = The slopes/gradients
$\alpha_{sars\text{-}cov\text{-}2}$ = The Intercept of the regression line on $Y_{sars\text{-}cov\text{-}2}$
$\xi_{sars\text{-}cov\text{-}2}$ = The error of computation of the regression equation = 0 (in this case)

The intercept (α) of the regression equation was calculated thus:

$$\alpha_{sars\text{-}cov\text{-}2} = \hat{Y}_{sars\text{-}cov\text{-}2} - (\beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \ldots\ldots + \beta_{26}X_{26})$$

$$\alpha_{sars-cov-2} = \overline{Y}_{sars-cov-2} - (\beta_1\overline{X_1} + \beta_2\overline{X_2} + \beta_3\overline{X_3} + \beta_4\overline{X_4} + \ldots\ldots + \beta_{26}\overline{X}_{26})$$

where $\hat{Y}_{sars\text{-}cov\text{-}2}$ = The mean value of the response variable

$X_1 \rightarrow X_{26}$ = The mean value of each predictor

The slopes or gradients ($\beta_i$) of the regression equation was calculated by the formula:

$$\beta_i = b_i \frac{SD_X}{SD_Y} = b_i \sqrt{\frac{V_X}{V_Y}}$$

$$\beta_i = b_i \frac{SD_x}{SD_y} = b_i \sqrt{\frac{V_x}{V_y}} = b_i \left[\frac{V_x}{V_y}\right]^{\frac{1}{2}}$$

where $b_i$ = Unstandardized gradient of the equation

$SD_X$ = The standard deviation of X (Predictors)
$SD_Y$ = The standard deviation of Y (Response variable)
$V_X$ = The variance of X (Predictors)
$V_Y$ = The variance of Y (Response variable)

**Note**: The equation provided for the calculation of $\beta_i$ for each of the predictor variables "$X_1$, $X_2$, $X_3$, ….$X_{26}$" is far more complex than what was presented in this article. The formula of the gradient shown above, is a simplistic representation of the gradient of the regression equation.

The equation generated was described thus:

$$Y_{sars\text{-}cov\text{-}2} = -1.09*10^{-14} + 20(X_1) + 20(X_2) + 20(X_3) + 2(X_4) + 2(X_5) + 2(X_6) + 2(X_7) + 2(X_8) + 2(X_9) + 2(X_{10}) + 2(X_{11}) + 2(X_{12}) + 2(X_{13}) + 2(X_{14}) + 2(X_{15}) + X_{16} + X_{17} + 2(X_{18}) + 2(X_{19}) + 2(X_{20}) + 2(X_{21}) + 2(X_{22}) + X_{23} + X_{24} + X_{25} + X_{26} + 0$$

The model statistics for Etaware-CDT-2020 was defined in Table 6. The proportion of variance in the response variable "$Y_{sars\text{-}cov\text{-}2}$" was determined by coefficient of determination ($R^2$) described by the

**Table 4**
Characterization of 4,856 virtual COVID-19 patients from China based on their medical status.

| S/N | Medical Condition | Case (%) | Population | Sample | Severity (%) | Midpoint (Ŷ) |
|---|---|---|---|---|---|---|
| 1 | Death | 10.83 | 526 | 13 | 90–100 | 95.0 |
| 2 | ICU | 10.83 | 526 | 13 | 80–89 | 84.5 |
| 3 | MV/OM/MOD/IV | 8.33 | 405 | 10 | 70–79 | 74.5 |
| 4 | ARD/Critical/Fatal | 12.50 | 607 | 15 | 60–69 | 64.5 |
| 5 | Infected (Severe) | 8.33 | 405 | 10 | 50–59 | 54.5 |
| 6 | Infected (Stable Conditions)/SARS/MERS/RD | 8.33 | 405 | 10 | 40–49 | 44.5 |
| 7 | RD/Early signs of Infection | 9.16 | 445 | 11 | 30–39 | 34.5 |
| 8 | RD/Suspected case | 10.83 | 526 | 13 | 20–29 | 24.5 |
| 9 | RD/Asymptomatic Patients | 8.33 | 405 | 10 | 10–19 | 14.5 |
| 10 | Digestive Disorder/Asymptomatic Patients | 10.83 | 526 | 13 | 1–9 | 4.5 |
| 11 | Discharged/Healthy | 1.67 | 81 | 02 | Below 1 | 0.5 |
| | **Total** | **100.0** | **(N = 4,856 Patients)** | **(n = 120 Patients)** | | |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, OM → Oxygen Mask, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, SARS → Severe Acute Respiratory Syndrome, MERS → Middle East Respiratory Syndrome, RD → Respiratory Distress, IV → Invasive Ventilation, SCD-B → Suspect Case Definition Boundary for COVID-19 infection, Ŷ→Class Midpoint/Mean value of COVID-19 infection calculated from the SCD-B value. The data for the virtual samples (120 patients) used for this experiment is available in Supplementary File "S1".

**Table 5**
Summary of rRT-PCR data for COVID-19 infected patients obtained in China.

| Symptoms | Wuhan, China | | | All Provinces (China) | | | Provinces (China) | | | Hubei, China (Epicentre) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cases (%) | Size (N) | Sample | Cases (%) | Size (N) | Sample | Cases (%) | Size (N) | Sample | Cases (%) | Size (N) | Sample |
| Fever | >90 | 38 | 38 | 87.3 | 40, 996 | 88 | 88.72 | 976 | 89 | ≤100.0 | 204 | 204 |
| Dry Cough | 80 | 33 | 33 | 58.1 | 27,284 | 59 | 67.80 | 746 | 68 | – | – | – |
| Fatigue | – | – | – | 35.5 | 16,671 | 36 | – | – | – | – | – | – |
| Malaise | >90 | 38 | 38 | – | – | – | – | – | – | – | – | – |
| Pneumonia | – | – | – | 75.7 | 35,548 | 76 | – | – | – | – | – | – |
| Shortness of Breath | 20 | 09 | 09 | 38.3 | 17,986 | 39 | – | – | – | – | – | – |
| RD | 15 | 07 | 07 | 28.8 | 13,525 | 29 | – | – | – | – | – | – |
| Diarrhoea | – | – | – | – | – | – | 3.80 | 42 | 04 | 17.16 | 35 | 35 |
| Vomiting | – | – | – | – | – | – | – | – | – | 1.96 | 04 | 04 |
| Abdominal Pain | – | – | – | – | – | – | – | – | – | 0.98 | 02 | 02 |
| Lack of Appetite | – | – | – | – | – | – | – | – | – | 39.71 | 81 | 81 |
| Discharged | 14 | 06 | 06 | – | – | – | – | – | – | – | – | – |
| Critical care | 15 | 07 | 07 | – | – | – | – | – | – | – | – | – |
| Death | 02 | 01 | 01 | – | – | – | 1.40 | 16 | 02 | – | – | – |
| Stable conditions | 66 | 27 | 27 | – | – | – | – | – | – | – | – | – |
| Chest Distress | – | – | – | 31.2 | 14,652 | 32 | – | – | – | – | – | – |
| GGO | – | – | – | 69.9 | 32,825 | 70 | – | – | – | – | – | – |
| Patients in ICU | – | – | – | 29.3 | 13,759 | 30 | 5.00 | 55 | 05 | – | – | – |
| ARD | – | – | – | 28.8 | 13,525 | 29 | – | – | – | – | – | – |
| Patients with GI | – | – | – | – | – | – | – | – | – | 18.63 | 38 | 38 |
| Fatality/Critical | – | – | – | 6.80 | 3,194 | 07 | – | – | – | – | – | – |
| MOD | – | – | – | 8.50 | 3,992 | 09 | – | – | – | – | – | – |
| MV | – | – | – | – | – | – | 2.30 | 26 | 03 | – | – | – |
| Total Patients | 100 | N = 41 | n = 41 | 100 | N = 46,959 | n = 100 | 100 | N = 1,099 | n = 100 | 100 | N = 204 | n = 204 |
| No. of Hospitals | – | | | – | | | 552 | | | – | | |
| No. of Districts | – | | | 34 | | | 30 | | | 13 | | |
| No. of Province | – | | | 23 | | | – | | | 01 | | |
| Source | [18 ] | | | [4 ] | | | [15] | | | [27] | | |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, RD → Respiratory Distress, GGO → Ground-glass Opacification. **Note**: *Some prominent symptoms associated with fever which are synonymous to COVID-19 infection were included for patients having fever by the author.* The data is presented in Supplementary File "S2".

formula:

$$R^2 = \frac{SS_{Regression}}{SS_{Total}}$$

While,

The coefficient of correlation (standardized covariance), the adjusted- and predicted $R^2$ for the regression model was calculated thus:

$$R = \sqrt{R^2}$$

where $R^2$ = The coefficient of determination

$$Adj.R^2 = 1 - \left[\frac{n-1}{n-(k+1)}\right](1-R^2)$$

where n = The sample size, k = The number of predictors, and $R^2$ = The coefficient of determination

$$Pred.R^2 = \frac{1 - PRESS}{SS_{Total}}$$

where PRESS = The predicted residual error sum of squares, $R^2$ = The coefficient of determination, and $SS_{total}$ = The total sum of squares

The model statistics showed that R = 1.00, $R^2$ = 1.00, Adj. $R^2$ = 1.00 and Pred. $R^2$ = 1.00, respectively (Table 6). The accuracy of Etaware-CDT-2020 was rated as 98.9% (as defined by SPSS version 20), this was shown in Fig. 2. The structured prototype system for COVID-19 infection detection "Etaware-CDT-2020" was shown in Fig. 3a and b.

### 3.5. Multicollinearity test for independent variables

The test for multicollinearity among the predictors or independent variables used in structuring the regression model (prototype) was measured by the variable inflation factor (VIF) and tolerance limit (T). "VIF" and "T" were described by the formulae below:

$$VIF(\beta_i) = \frac{1}{1-R^2} \text{ and } T = \frac{1}{VIF(\beta_i)}$$

The coefficient of determination used in this equation ($R^2$) was calculated from the ordinary least square regression equation (OLSRE) described thus:

$$X_i(if\ X_i = X_1) = -\alpha_{sars-cov-2} + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \ldots\ldots + \alpha_{26} X_{26} + \xi_{sars-cov-2}$$

where $X_i = X_1, X_2, X_3, \ldots\ldots\ldots X_n$.

If VIF ($\beta_i$) > 10, then the multicollinearity level of that independent variable compared to other variable is very high and it will affect the efficiency of the model whenever a slight change is made to the predictors. The primary data used for the estimation of VIF and T can be found in Supplementary File "S1".

1. Fever (Predictor $X_1$)
   Ordinary least square regression equation
   $X_1 = 0.27 + 0.28X_2 + 0.05X_3 + 0.50X_4 - 0.32X_5 - 0.21X_6 \ldots\ldots\ldots\ldots\ldots\ldots + 0.11X_{25} - 0.02X_{26}$
   Model Statistics: S = 0.41, $R^2$ = 45.63%, Adj. $R^2$ = 31.17%, PRESS = 28.39, Pred. $R^2$ = 3.20%
   VIF ($\beta_1$) = 1.84 and T = 0.54 (VIF ($\beta_1$) < 5, "$X_1$" is independently associated with other variables)
2. Dry or Chesty Cough (Predictor $X_2$)
   Ordinary least square regression equation
   $X_2 = 0.29 + 0.25X_1 + 0.19X_3 - 0.07X_4 + 0.54X_5 - 0.04X_6 \ldots\ldots\ldots\ldots - 0.01X_{25} - 0.08X_{26}$
   Model Statistics: S = 0.39, $R^2$ = 50.45%, Adj. $R^2$ = 37.28%, PRESS = 23.47, Pred. $R^2$ = 20.34%
   VIF ($\beta_2$) = 2.02 and T = 0.50 (VIF ($\beta_2$) < 5, "$X_2$" is independently associated with other variables)
3. Fatigue or Tiredness (Predictor $X_3$)
   Ordinary least square regression equation

**Table 6**
Etaware-CDT-2020 statistics and the relationship between "$Y_{sars\text{-}cov\text{-}2}$" and all the "X" values.

| Description | | Variable Stat | | Etaware-CDT-2020 Stat | | | |
|---|---|---|---|---|---|---|---|
| Symbol | Symptoms represented | R | $R^2$ | R | $R^2$ | Adj. $R^2$ | Pred. $R^2$ |
| $Y_{sars\text{-}cov\text{-}2}$ | COVID-19 Infection | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| $\alpha_{sars\text{-}cov\text{-}2}$ | Intercept on $Y_{sars\text{-}cov\text{-}2}$ | – | – | | | | |
| $X_1$ | Fever | 0.74 | 0.55 | | | | |
| $X_2$ | Dry or Chesty Cough | 0.74 | 0.55 | | | | |
| $X_3$ | Fatigue or Tiredness | 0.77 | 0.59 | | | | |
| $X_4$ | Shortness of breath | 0.81 | 0.66 | | | | |
| $X_5$ | Muscular aches and pains (Myalgia) | 0.80 | 0.64 | | | | |
| $X_6$ | Chill or Shivering | 0.72 | 0.52 | | | | |
| $X_7$ | Sore throat | 0.69 | 0.48 | | | | |
| $X_8$ | Headache | 0.65 | 0.42 | | | | |
| $X_9$ | Diarrhoea | 0.69 | 0.48 | | | | |
| $X_{10}$ | Vomiting or Nausea | 0.63 | 0.40 | | | | |
| $X_{11}$ | Drowsiness | 0.59 | 0.35 | | | | |
| $X_{12}$ | Loss of appetite | 0.52 | 0.27 | | | | |
| $X_{13}$ | Loss of sense of smell | 0.44 | 0.19 | | | | |
| $X_{14}$ | Loss of sense of taste | 0.33 | 0.11 | | | | |
| $X_{15}$ | Nasal congestion | 0.15 | 0.02 | | | | |
| $X_{16}$ | Stroke | 0.36 | 0.13 | | | | |
| $X_{17}$ | Pneumonia | 0.31 | 0.10 | | | | |
| $X_{18}$ | Abdominal pain | 0.10 | 0.01 | | | | |
| $X_{19}$ | Chest pain | 0.12 | 0.01 | | | | |
| $X_{20}$ | Neurological illness | 0.03 | 0.00 | | | | |
| $X_{21}$ | Gastrointestinal illness | −0.03 | 0.00 | | | | |
| $X_{22}$ | Dizziness | −0.08 | 0.01 | | | | |
| $X_{23}$ | High body temperature | 0.16 | 0.03 | | | | |
| $X_{24}$ | Rhinorrhoea (Runny nose) | 0.23 | 0.05 | | | | |
| $X_{25}$ | Body rash | 0.12 | 0.01 | | | | |
| $X_{26}$ | Conjunctivitis | 0.13 | 0.02 | | | | |
| $\xi_{sars\text{-}cov\text{-}2}$ | Correction factor | – | – | | | | |

The data is available in Supplementary File "S3".

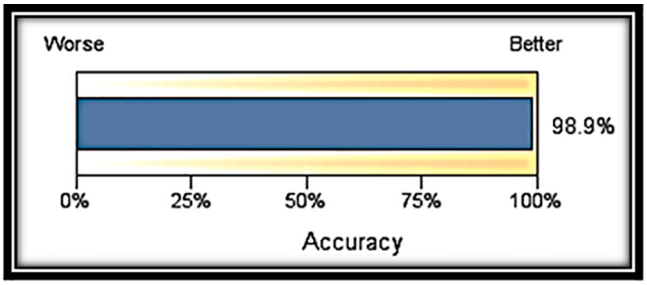


**Fig. 2.** The accuracy of the computer program "Etaware-CDT-2020" as described by SPSS.

$X_3 = 0.16 + 0.04X_1 + 0.16X_2 + 0.28X_4 + 0.35X_5 - 0.036X_6$ …… $- 0.11X_{25} + 0.13X_{26}$
Model Statistics: S = 0.36, $R^2$ = 58.24%, Adj. $R^2$ = 47.13%, PRESS = 19.35, Pred. $R^2$ = 35.35%
VIF ($\beta_3$) = 2.39 and T = 0.42 (VIF ($\beta_3$) < 5, "$X_3$" is independently associated with other variables)

4. Shortness of breath (Predictor $X_4$)
   Ordinary least square regression equation
   $X_4$ = -0.02 + 0.14$X_1$ − 0.02$X_2$ + 0.10$X_3$ + 0.66$X_5$ + 0.18$X_6$……. + 0.04$X_{25}$ − 0.02$X_{26}$
   Model Statistics: S = 0.22, $R^2$ = 84.91%, Adj. $R^2$ = 80.89%, PRESS = 7.44, Pred. $R^2$ = 75.19%
   VIF ($\beta_4$) = 6.62 and T = 0.15 (VIF ($\beta_4$) < 10, "$X_4$" is independently associated with other variables)
5. Muscular aches and pains (Myalgia) (Predictor $X_5$)
   Ordinary least square regression equation
   $X_5$ = -0.03–0.06$X_1$ + 0.10$X_2$ + 0.08$X_3$ + 0.42$X_4$ + 0.48$X_6$ …….. − 0.11$X_{25}$ + 0.02$X_{26}$
   Model Statistics: S = 0.17, $R^2$ = 90.48%, Adj. $R^2$ = 87.95%, PRESS = 5.61, Pred. $R^2$ = 81.29%
   VIF ($\beta_5$) = 10.50 and T = 0.54 (VIF ($\beta_5$) > 10, "$X_5$" may be influenced by other variables)
6. Chill or Shivering (Predictor $X_6$)
   Ordinary least square regression equation
   $X_6$ = 0.05–0.03$X_1$ +……0.40$X_5$ + 0.58$X_7$ − 0.01$X_8$ − 0.03$X_9$…… + 0.10$X_{25}$ − 0.03$X_{26}$
   Model Statistics: S = 0.16, $R^2$ = 92.02%, Adj. $R^2$ = 89.90%, PRESS = 4.34, Pred. $R^2$ = 85.45%
   VIF ($\beta_6$) = 12.53 and T = 0.08 (VIF ($\beta_6$) > 10, "$X_6$" may be influenced by other variables)
7. Sore throat (Predictor $X_7$)
   Ordinary least square regression equation
   $X_7$ = -0.05 + 0.05$X_1$……. + 0.37$X_6$ + 0.71$X_8$ − 0.05$X_9$ + 0.01$X_{10}$…… − 0.07$X_{25}$ + 0.07$X_{26}$
   Model Statistics: S = 0.13, $R^2$ = 94.94%, Adj. $R^2$ = 93.59%, PRESS = 2.41, Pred. $R^2$ = 91.93%
   VIF ($\beta_7$) = 19.75 and T = 0.05 (VIF ($\beta_7$) > 10, "$X_7$" may be influenced by other variables)
8. Headache (Predictor $X_8$)
   Ordinary least square regression equation
   $X_8$ = 0.07–0.03$X_1$ …. + 0.79$X_7$ + 0.27$X_9$ − 0.05$X_{10}$ + 0.04$X_{11}$ …… + 0.03$X_{25}$ − 0.05$X_{26}$
   Model Statistics: S = 0.13, $R^2$ = 94.37%, Adj. $R^2$ = 92.87%, PRESS = 2.62, Pred. $R^2$ = 91.25%
   VIF ($\beta_8$) = 17.75 and T = 0.06 (VIF ($\beta_8$) > 10, "$X_8$" may be influenced by other variables)
9. Diarrhoea (Predictor $X_9$)
   Ordinary least square regression equation
   $X_9$ = -0.05 + …… + 0.48$X_8$ + 0.63$X_{10}$ − 0.08$X_{11}$ + 0.01$X_{12}$ ……..…. + 0.07$X_{25}$ − 0.05$X_{26}$
   Model Statistics: S = 0.18, $R^2$ = 89.94%, Adj. $R^2$ = 87.27%, PRESS = 4.90, Pred. $R^2$ = 83.50%
   VIF ($\beta_9$) = 9.94 and T = 0.10 (VIF ($\beta_9$) < 10, "$X_9$" is independently associated with other variables)
10. Vomiting or Nausea (Predictor $X_{10}$)
    Ordinary least square regression equation
    $X_{10}$ = 0.03 + 0.04$X_1$ … + 0.66$X_9$ + 0.37$X_{11}$ + 0.002$X_{12}$ + 0.09$X_{13}$ … − 0.06$X_{25}$ + 0.05$X_{26}$
    Model Statistics: S = 0.18, $R^2$ = 89.39%, Adj. $R^2$ = 86.56%, PRESS = 4.86, Pred. $R^2$ = 83.49%
    VIF ($\beta_{10}$) = 9.42 and T = 0.11 (VIF ($\beta_{10}$) < 10, "$X_{10}$" functions independently with other variables)
11. Drowsiness (Predictor $X_{11}$)
    Ordinary least square regression equation
    $X_{11}$ = -0.01–0.03$X_1$ ….. + 0.43$X_{10}$ + 0.61$X_{12}$ − 0.01$X_{13}$ + 0.04$X_{14}$ + ….. 0.03$X_{25}$ − 0.01$X_{26}$
    Model Statistics: S = 0.20, $R^2$ = 87.43%, Adj. $R^2$ = 84.08%, PRESS = 5.22, Pred. $R^2$ = 81.75%
    VIF ($\beta_{11}$) = 7.95 and T = 0.13 (VIF ($\beta_{11}$) < 10, "$X_{11}$" functions independently with other variables)
12. Loss of appetite (Predictor $X_{12}$)
    Ordinary least square regression equation

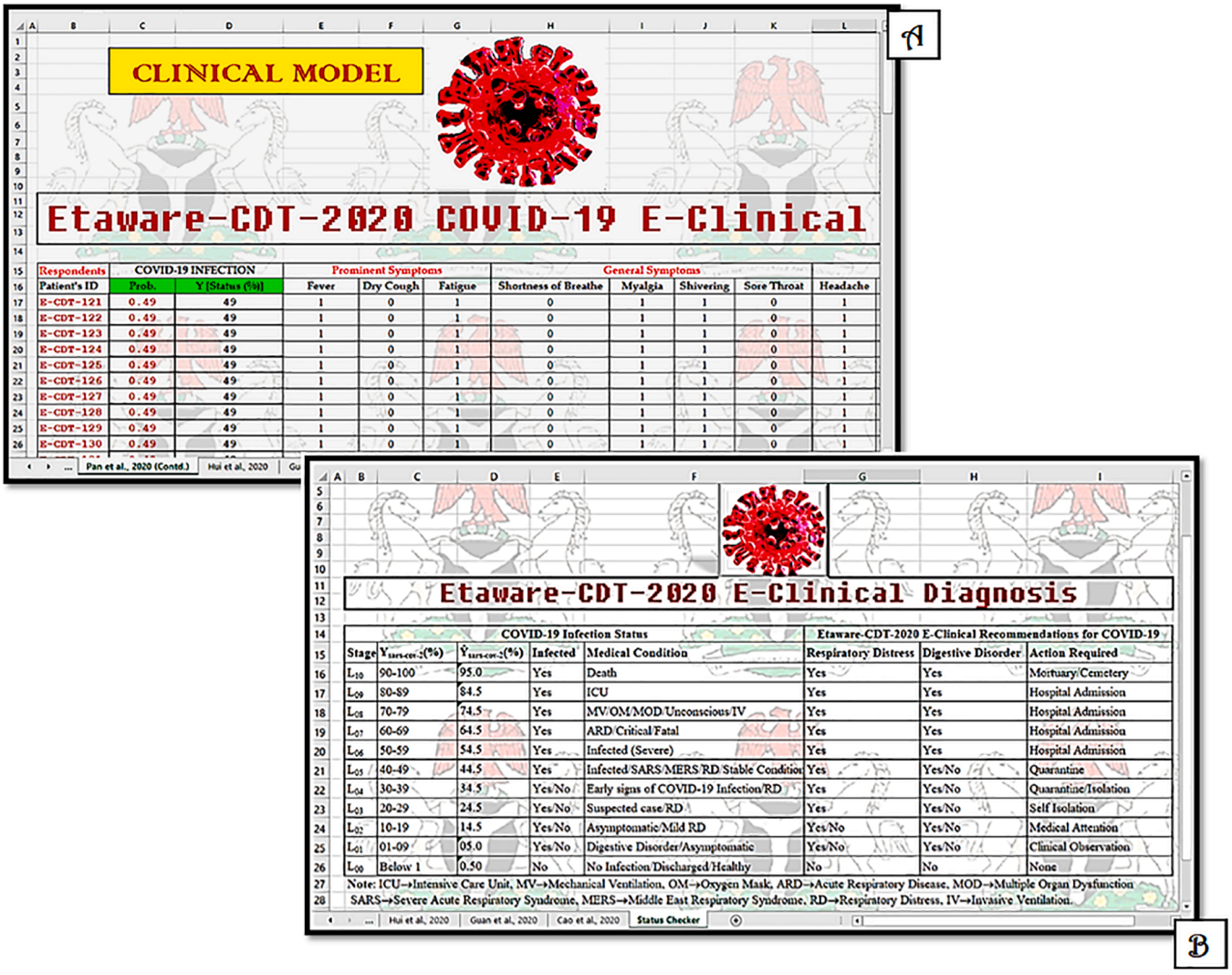


**Fig. 3.** Etaware-CDT-2020 RCD model (a) Clinical model (b) COVID-19 Infection Status.

$X_{12}$ = -0.02 + 0.04$X_1$…. + 0.50$X_{11}$ + 0.49$X_{13}$ + 0.003$X_{14}$ − 0.04$X_{15}$ ……. + 0.004$X_{26}$

Model Statistics: S = 0.18, $R^2$ = 89.59%, Adj. $R^2$ = 86.82%, PRESS = 4.05, Pred. $R^2$ = 85.61%

VIF ($\beta_{12}$) = 9.61 and T = 0.10 (VIF ($\beta_{12}$) < 10, "$X_{12}$" functions independently with other variables)

13. Loss of sense of smell (Predictor $X_{13}$)

Ordinary least square regression equation

$X_{13}$ = -0.02–0.02$X_1$ ….. + 0.52$X_{12}$ + 0.47$X_{14}$ − 0.04$X_{15}$ + 0.03$X_{16}$ … + 0.02$X_{25}$ − 0.002$X_{26}$

Model Statistics: S = 0.18, $R^2$ = 88.72%, Adj. $R^2$ = 85.72%, PRESS = 4.42, Pred. $R^2$ = 83.99%

VIF ($\beta_{13}$) = 8.86 and T = 0.11 (VIF ($\beta_{13}$) < 10, "$X_{13}$" functions independently with other variables)

14. Loss of sense of taste (Predictor $X_{14}$)

Ordinary least square regression equation

$X_{14}$ = -0.02 + 0.01$X_1$ ……+ 0.56$X_{13}$ + 0.50$X_{15}$ − 0.15$X_{16}$ ……. + 0.02$X_{25}$ + 0.01$X_{26}$

Model Statistics: S = 0.20, $R^2$ = 86.69%, Adj. $R^2$ = 83.15%, PRESS = 5.45, Pred. $R^2$ = 80.43%

VIF ($\beta_{14}$) = 7.51 and T = 0.13 (VIF ($\beta_{14}$) < 10, "$X_{14}$" function independently with other variables)

15. Nasal congestion (Predictor $X_{15}$)

Ordinary least square regression equation

$X_{15}$ = 0.13–0.03$X_1$ …… + 0.64$X_{14}$ + 0.48$X_{16}$ − 0.11$X_{17}$ − 0.06$X_{18}$…… − 0.02$X_{25}$ − 0.02$X_{26}$

Model Statistics: S = 0.22, $R^2$ = 83.21%, Adj. $R^2$ = 78.75%, PRESS = 7.77, Pred. $R^2$ = 72.38%

VIF ($\beta_{15}$) = 5.96 and T = 0.17 (VIF ($\beta_{15}$) < 10, "$X_{15}$" functions independently with other variables)

16. Stroke (Predictor $X_{16}$)

Ordinary least square regression equation

$X_{16}$ = -0.12 + 0.01$X_1$ …+ 0.22$X_{15}$ + 0.67$X_{17}$ − 0.03$X_{18}$ + 0.06$X_{19}$…… − 0.01$X_{25}$ + 0.06$X_{26}$

Model Statistics: S = 0.15, $R^2$ = 89.76%, Adj. $R^2$ = 87.04%, PRESS = 4.38, Pred. $R^2$ = 79.60%

VIF ($\beta_{16}$) = 9.77 and T = 0.10 (VIF ($\beta_{16}$) < 10, "$X_{16}$" functions independently with other variables)

17. Pneumonia (Predictor $X_{17}$)

Ordinary least square regression equation

$X_{17}$ = 0.09 + 0.01$X_1$ … + 0.91$X_{16}$ + 0.06$X_{18}$ + 0.14$X_{19}$ + 0.11$X_{20}$…… + 0.01X25 − 0.08$X_{26}$

Model Statistics: S = 0.18, $R^2$ = 87.33%, Adj. $R^2$ = 83.96%, PRESS = 5.40, Pred. $R^2$ = 76.99%

VIF ($\beta_{17}$) = 7.89 and T = 0.13 (VIF ($\beta_{17}$) < 10, "$X_{17}$" functions independently with other variables)

18. Abdominal pain (Predictor $X_{18}$)

Ordinary least square regression equation

**Table 7**
Comparison between the COVID-19 diagnosis of Hui et al. [18] and Etaware-CDT-2020.

| Demographics | | COVID-19 Diagnosis in Wuhan (2020) | | Statistics | | | |
|---|---|---|---|---|---|---|---|
| Stage | Medical Condition | rRT-PCR (%) | Etaware-CDT-2020 (%) | r | $\chi^2$ | | Prob. |
| $L_{10}$ | Death | 2.4 | 0.0 | 0.92 | 33.2 | | 0.07 |
| $L_{09}$ | ICU | 0.0 | 0.0 | | | **T-test** | **P(t = 0)** |
| $L_{08}$ | MV/OM/MOD/IV | 0.0 | 0.0 | | | $-1.9 \times 10^{-16}$ | 1.0 ns |
| $L_{07}$ | ARD/Critical/Fatal | 0.0 | 0.0 | | | | |
| $L_{06}$ | Infected (Severe) | 0.0 | 22.0 | | | | |
| $L_{05}$ | Infected (Stable) | 65.9 | 58.5 | | | | |
| $L_{04}$ | RD/Early Infection | 0.0 | 0.0 | | | | |
| $L_{03}$ | RD/Suspected case | 17.1 | 12.2 | | | | |
| $L_{02}$ | RD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{01}$ | DD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{00}$ | Discharged/Healthy | 14.6 | 7.3 | | | | |
| | Total: | **100%** | **100%** | | | | |
| | Patient's Population: | **N = 41** | **N = 41** | | | | |
| | Source: | Hui et al. [18] | Etaware-CDT-2020 | | | | |
| | Provincial-Levels: | – | – | | | | |
| | Province: | – | – | | | | |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, DD → Digestive Disorder, RD → Respiratory Distress, GGO → Ground-glass Opacification. The data is available in Supplementary File "S4" and "S5".

**Table 8**
Comparison between the COVID-19 diagnosis of Pan et al. [27] and Etaware-CDT-2020.

| Demographics | | COVID-19 Diagnosis in Hubei (2020) | | Statistics | | | |
|---|---|---|---|---|---|---|---|
| Stage | Medical Condition | rRT-PCR (%) | Etaware-CDT-2020 (%) | r | $\chi^2$ | | Prob. |
| $L_{10}$ | Death | 0.0 | 0.0 | 0.97 | 11.0 | | 0.04 |
| $L_{09}$ | ICU | 0.0 | 0.0 | | | **T-test** | **P(t = 0)** |
| $L_{08}$ | MV/OM/MOD/IV | 0.0 | 0.0 | | | $2.9 \times 10^{-16}$ | 1.0 ns |
| $L_{07}$ | ARD/Critical/Fatal | 0.0 | 0.0 | | | | |
| $L_{06}$ | Infected (Severe) | 0.0 | 18.6 | | | | |
| $L_{05}$ | Infected (Stable) | 100.0 | 81.4 | | | | |
| $L_{04}$ | RD/Early Infection | 0.0 | 0.0 | | | | |
| $L_{03}$ | RD/Suspected case | 0.0 | 0.0 | | | | |
| $L_{02}$ | RD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{01}$ | DD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{00}$ | Discharged/Healthy | 0.0 | 0.0 | | | | |
| | Total: | **100%** | **100%** | | | | |
| | Patient's Population: | **N = 204** | **N = 204** | | | | |
| | Source: | Pan et al. [27] | Etaware-CDT-2020 | | | | |
| | Provincial-Levels: | 13 | 13 | | | | |
| | Province: | 01 | 01 | | | | |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, DD → Digestive Disorder, RD → Respiratory Distress, GGO → Ground-glass Opacification. The data is available in Supplementary File "S4" and "S5".

$X_{18} = 0.01–0.05\ X_1$ …… $+ 0.03X_{17} + 0.97X_{19} + 0.02X_{20} - 0.01X_{21}$…… $- 0.13X_{25} + 0.08X_{26}$
Model Statistics: S = 0.13, $R^2$ = 94.11%, Adj. $R^2$ = 92.54%, PRESS = 2.30, Pred. $R^2$ = 91.15%
VIF ($\beta_{18}$) = 16.97 and T = 0.06 (VIF ($\beta_{18}$) > 10, "$X_{18}$" may be influenced by other variables)

19. Chest pain (Predictor $X_{19}$)
Ordinary least square regression equation
$X_{19} = -0.01 + 0.03X_1$ ……. $+ 0.65X_{18} + 0.22X_{20} + 0.03X_{21} + 0.023X_{22} + 0.08X_{25} - 0.04X_{26}$
Model Statistics: S = 0.10, $R^2$ = 96.14%, Adj. $R^2$ = 95.11%, PRESS = 1.98, Pred. $R^2$ = 92.57%
VIF ($\beta_{19}$) = 25.88 and T = 0.04 (VIF ($\beta_{19}$) > 10, "$X_{19}$" may be influenced by other variables)

20. Neurological illness (Predictor $X_{20}$)
Ordinary least square regression equation
$X_{20} = 0.03$ ……$+ 0.51X_{19} + 0.49X_{21} + 0.003X_{22} + 0.001X_{23} + 0.06X_{24} - 0.02X_{25} - 0.03X_{26}$
Model Statistics: S = 0.16, $R^2$ = 91.26%, Adj. $R^2$ = 88.93%, PRESS = 3.88, Pred. $R^2$ = 85.63%
VIF ($\beta_{20}$) = 11.44 and T = 0.09 (VIF ($\beta_{20}$) > 10, "$X_{20}$" may be influenced by other variables)

21. Gastrointestinal illness (Predictor $X_{21}$)
Ordinary least square regression equation
$X_{21} = 0.02$ …… $+ 0.59X_{20} + 0.39X_{22} + 0.02X_{23} - 0.05X_{24} + 0.02X_{25} + 0.01X_{26}$
Model Statistics: S = 0.17, $R^2$ = 89.37%, Adj. $R^2$ = 86.54%, PRESS = 4.88, Pred. $R^2$ = 81.70%
VIF ($\beta_{21}$) = 9.41 and T = 0.11 (VIF ($\beta_{21}$) < 10, "$X_{21}$" functions independently with other variables)

22. Dizziness (Predictor $X_{22}$)
Ordinary least square regression equation
$X_{22} = 0.06–0.01X_1$ …….. $+ 0.67X_{21} + 0.27X_{23} + 0.14X_{24} - 0.07X_{25} - 0.01X_{26}$
Model Statistics: S = 0.23, $R^2$ = 81.79%, Adj. $R^2$ = 76.95%, PRESS = 8.49, Pred. $R^2$ = 68.16%
VIF ($\beta_{22}$) = 5.49 and T = 0.18 (VIF ($\beta_{22}$) < 10, "$X_{22}$" functions independently with other variables)

23. High body temperature (Predictor $X_{23}$)
Ordinary least square regression equation
$X_{23} = 0.07 + 0.01X_1$ …….…… $+ 0.42X_{22} + 0.43X_{24} - 0.01X_{25} - 0.07X_{26}$
Model Statistics: S = 0.28, $R^2$ = 62.96%, Adj. $R^2$ = 53.11%, PRESS = 12.91, Pred. $R^2$ = 36.61%
VIF ($\beta_{23}$) = 2.70 and T = 0.37 (VIF ($\beta_{23}$) < 5, "$X_{23}$" functions independently with other variables)

24. Rhinorrhoea (Runny nose) (Predictor $X_{24}$)
Ordinary least square regression equation
$X_{24} = -0.05–0.06X_1 + 0.05X_2 - 0.04X_3$ …….. $+ 0.33X_{23} + 0.42X_{25} + 0.01X_{26}$
Model Statistics: S = 0.25, $R^2$ = 72.43%, Adj. $R^2$ = 65.10%, PRESS = 9.61, Pred. $R^2$ = 55.24%

**Table 9**
Comparison between the COVID-19 diagnosis of Guan et al. [15] and Etaware-CDT-2020.

| Demographics | | COVID-19 Diagnosis in China (2020) | | Statistics | | | |
|---|---|---|---|---|---|---|---|
| Stage | Medical Condition | rRT-PCR (%) | Etaware-CDT-2020 (%) | r | $\chi^2$ | | Prob. |
| $L_{10}$ | Death | 1.4 | 0.0 | 0.19 | 22.9 | | 0.12 |
| $L_{09}$ | ICU | 5.0 | 0.0 | | | **T-test** | **P(t = 0)** |
| $L_{08}$ | MV/OM/MOD/IV | 2.3 | 4.0 | | | $-4.9 \times 10^{-17}$ | 1.0 ns |
| $L_{07}$ | ARD/Critical/Fatal | 0.0 | 64.0 | | | | |
| $L_{06}$ | Infected (Severe) | 0.0 | 0.0 | | | | |
| $L_{05}$ | Infected (Stable) | 91.3 | 21.0 | | | | |
| $L_{04}$ | RD/Early Infection | 0.0 | 0.0 | | | | |
| $L_{03}$ | RD/Suspected case | 0.0 | 0.0 | | | | |
| $L_{02}$ | RD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{01}$ | DD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{00}$ | Discharged/Healthy | 0.0 | 11.0 | | | | |
| | Total: | **100%** | **100%** | | | | |
| | Patient's Population: | **N = 1,099** | **N = 100** | | | | |
| | Source: | Guan et al. [15] | Etaware-CDT-2020 | | | | |
| | Hospitals: | 552 | 552 | | | | |
| | Provincial-Levels: | 30 | 30 | | | | |
| | Province: | – | – | | | | |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, DD → Digestive Disorder, RD → Respiratory Distress, GGO → Ground-glass Opacification. The data is available in Supplementary File "S4" and "S5".

VIF ($\beta_{24}$) = 3.63 and T = 0.28 (VIF ($\beta_{24}$) < 5, "$X_{24}$" functions independently with other variables)

25. Body rash (Predictor $X_{25}$)
Ordinary least square regression equation
$X_{25} = 0.04 + 0.06X_1 - 0.01X_2 - 0.08X_3 + 0.07X_4$ …….. $+ 0.62X_{24} + 0.30X_{26}$
Model Statistics: S = 0.30, $R^2$ = 65.15%, Adj. $R^2$ = 55.88%, PRESS = 13.39, Pred. = 45.98%
VIF ($\beta_{25}$) = 2.87 and T = 0.35 (VIF ($\beta_{25}$) < 5, "$X_{25}$" functions independently with other variables)
26. Conjunctivitis (Predictor $X_{26}$)
Ordinary least square regression equation
$X_{26} = 0.41–0.02X_1 - 0.09X_2 + 0.18X_3 - 0.09X_4 + 0.12X_5$ …….. $+ 0.04X_{24} + 0.62X_{25}$
Model Statistics: S = 0.44, $R^2$ = 40.10%, Adj. $R^2$ = 24.17%, PRESS = 28.25, Pred. $R^2$ = 5.17%
VIF ($\beta_{26}$) = 1.67 and T = 0.60 (VIF ($\beta_{26}$) < 5, "$X_{26}$" functions independently with other variables)

### 3.6. Comparative diagnosis between rRT-PCR and Etaware-CDT-2020

The collinearity of the data generated by Etaware-CDT-2020 with that obtained from rRT-PCR was tested using the formula:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{\left[n\Sigma x^2 - (\Sigma x)^2\right]\left[n\Sigma y^2 - (\Sigma y)^2\right]}}$$

x = data generated by Etaware-CDT-2020
y = data obtained from the corresponding rRT-PCR file

The collinearity test showed that there was a positive relationship between the COVID-19 diagnosis conducted by Etaware-CDT-2020 and those reported by Hui et al. [18], for Wuhan patients (r = 0.92) and Pan et al. [27], for Hubei patients (r = 0.97), as shown in Tables 7 and 8 ($P < 0.05$). However, the correlation between the rRT-PCR COVID-19 diagnostic results and those generated by Etaware-CDT-2020 for patients tested in China was very small (r = 0.19 [ [15]] and 0.01 [ [4]], respectively). The data was further compared with the rRT-PCR results using the Pearson chi-square equation described below:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

$\chi^2$ = Pearson Chi-Square
O = Observed value
E = Expected value
i = Represents values across the row
j = Represents values down the column

The outcome of the comparison showed that the Pearson's Chi-Square value for Wuhan patients ($\chi^2$ = 33.2, Table 7) was not

**Table 10**
Comparison between the COVID-19 diagnosis of Cao et al. [4] and Etaware-CDT-2020.

| Demographics | | COVID-19 Diagnosis in China (2020) | | Statistics | | | |
|---|---|---|---|---|---|---|---|
| Stage | Medical Condition | rRT-PCR (%) | Etaware-CDT-2020 (%) | r | $\chi^2$ | | Prob. |
| $L_{10}$ | Death | 0.0 | 0.0 | 0.01 | 23.6 | | 0.10 |
| $L_{09}$ | ICU | 29.3 | 0.0 | | | **T-test** | **P(t = 0)** |
| $L_{08}$ | MV/OM/MOD/IV | 8.5 | 36.0 | | | $-3.95 \times 10^{-17}$ | 1.0 ns |
| $L_{07}$ | ARD/Critical/Fatal | 35.6 | 0.0 | | | | |
| $L_{06}$ | Infected (Severe) | 26.6 | 23.0 | | | | |
| $L_{05}$ | Infected (Stable) | 0.0 | 0.0 | | | | |
| $L_{04}$ | RD/Early Infection | 0.0 | 17.0 | | | | |
| $L_{03}$ | RD/Suspected case | 0.0 | 12.0 | | | | |
| $L_{02}$ | RD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{01}$ | DD/Asymp. | 0.0 | 0.0 | | | | |
| $L_{00}$ | Discharged/Healthy | 0.0 | 12.0 | | | | |
| | Total: | **100%** | **100%** | | | | |
| | Patient's Population: | **N = 46,959** | **N = 100** | | | | |
| | Source: | Cao et al. [4] | Etaware-CDT-2020 | | | | |
| | Provincial-Levels: | 34 | 34 | | | | |
| | Province: | 23 | 23 | | | | |

ICU → Intensive Care Unit, MV → Mechanical Ventilation, ARD → Acute Respiratory Disease, MOD → Multiple Organ Dysfunction, DD → Digestive Disorder, RD → Respiratory Distress, GGO → Ground-glass Opacification. The data is available in Supplementary File "S4" and "S5".

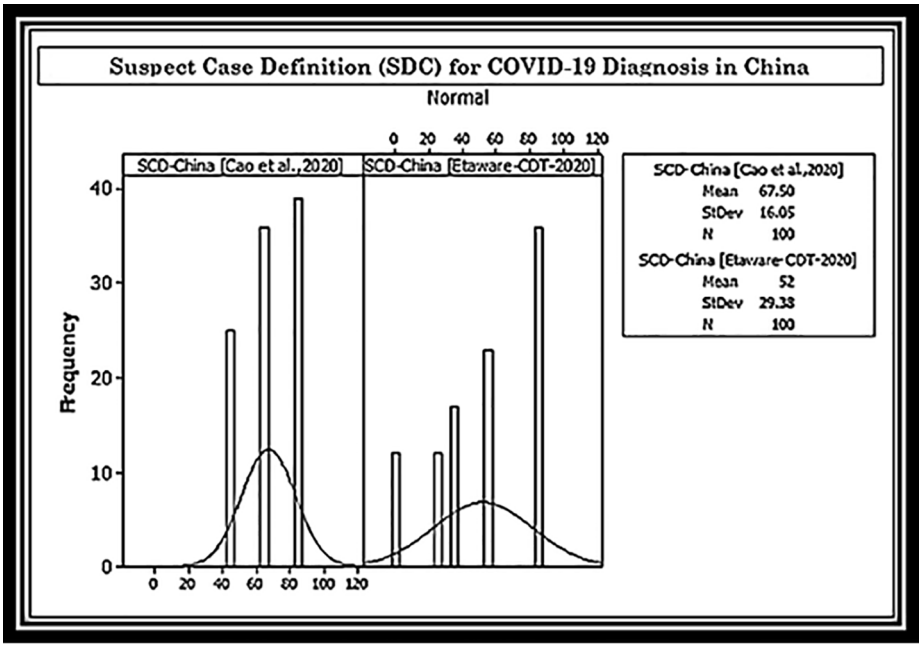


**Fig. 4.** Binomial distribution of COVID-19 patients in the 23 provinces of China.

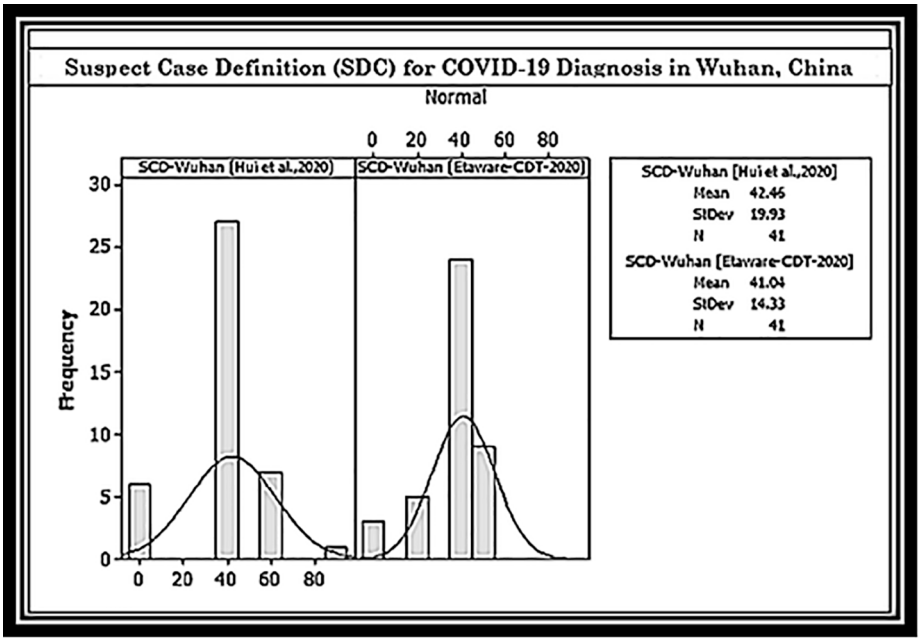


**Fig. 5.** Binomial distribution of COVID-19 patients in Wuhan.

significant, therefore, the rRT-PCR diagnostic result was possibly "matched" by the computer diagnosis generated by Etaware-CDT-2020, while that of Hubei patients ($X^2 = 11.0$, Table 8) was significant to those generated by Etaware-CDT-2020 at $P \leq 0.05$ ($P = 0.07$ and 0.04, respectively). The Pearson's chi-square test showed "no significance" difference or disparity in the COVID-19 infection diagnosis conducted and/or generated independently i.e., $\chi^2 = 22.9$ and 23.6, respectively; $P = 0.12$ and 0.10, respectively, for Chinese patients in general (Tables 9 and 10). Further test to ensure collinearity of diagnostic results was conducted using the correlated T-test equation described thus:

$$t = \frac{\overline{x_D}}{\left[\frac{S_D}{\sqrt{N}}\right]}$$

$$\text{Since, } \frac{\bar{x}}{x_D} = \frac{\left(\sum \mathrm{D}\right)}{N} \text{ and } \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\sum \mathrm{D}^2 - \left(\frac{\left(\sum_N \mathrm{D}\right)^2}{N}\right)}{(\mathrm{N}-1)(\mathrm{N})}}$$

$$\text{Since, } \overline{x_D} = \frac{(\Sigma D)}{N} \text{ and } \frac{S_D}{\sqrt{N}} = \sqrt{\frac{\Sigma D^2 - \left(\frac{(\Sigma D)^2}{N}\right)}{(N-1)(N)}}$$

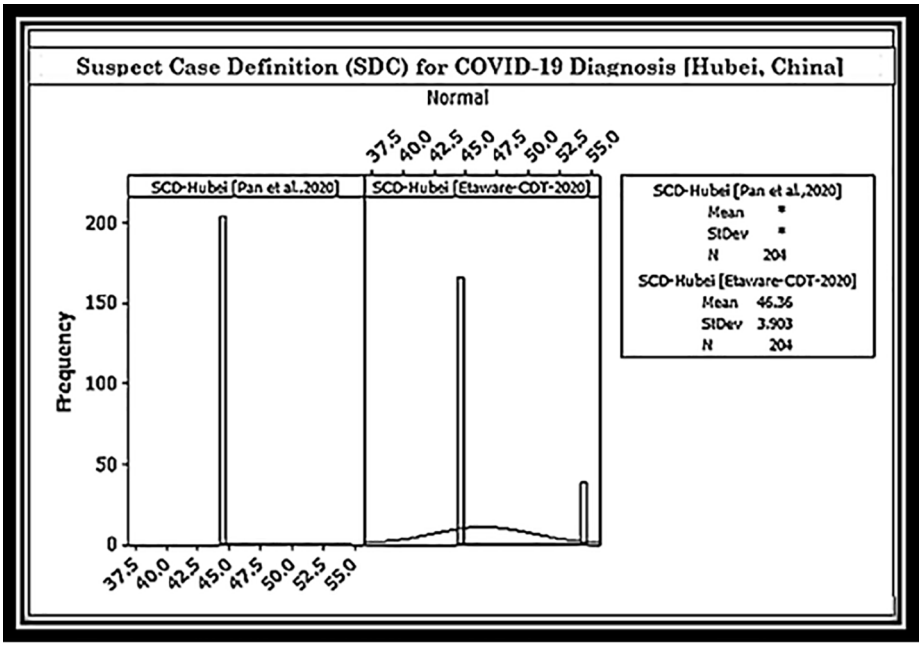


**Fig. 6.** Binomial distribution of COVID-19 patients in Hubei Province, China.

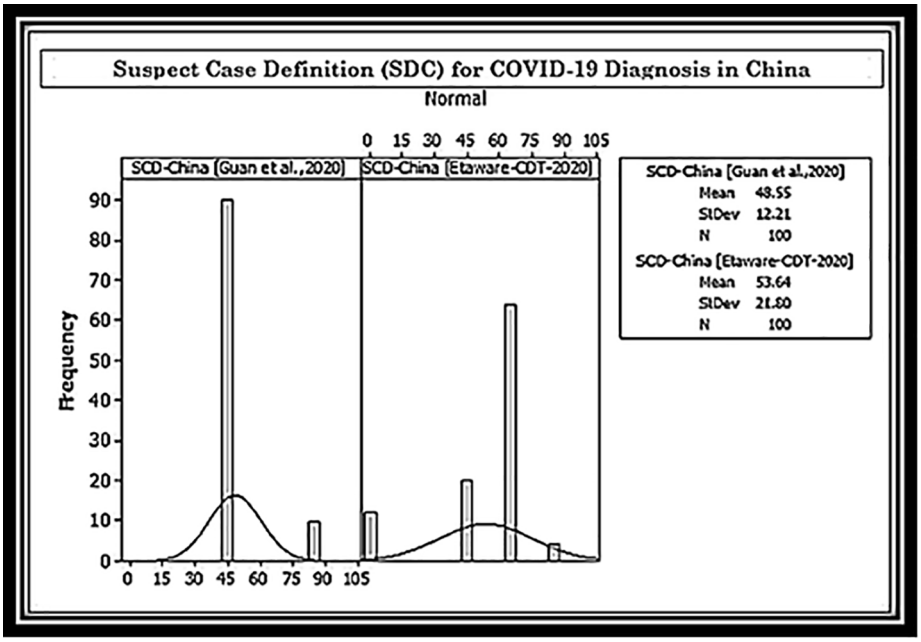


**Fig. 7.** Binomial distribution of COVID-19 patients in some hospitals in China.

Therefore,

$$t = \frac{\frac{(\Sigma D)}{N}}{\sqrt{\frac{\Sigma D^2 - \left(\frac{(\Sigma D)^2}{N}\right)}{(N-1)(N)}}}$$

D = x – y

x = data generated by Etaware-CDT-2020

y = data obtained from the corresponding rRT-PCR file

The T-test analysis conducted showed that there was no significant difference in the diagnosis carried out by the computer program "Etaware-CDT-2020" and those conducted using the rRT-PCR machine, for both Wuhan and Hubei patients i.e., $P(t = 0) > 0.05$ (Tables 7 and 8). Fortunately, the T-test conducted further reaffirmed the results obtained using the Pearson Chi-Square test, as the diagnoses were not significant ($P(t = 0) > 0.05$) to those generated by Etaware-CDT-2020 for Chinese patients infected with COVID-19 infection in general (Tables 9 and 10).

### 3.7. Contrast between binomial distribution of COVID-19 patients

There was perfect elasticity in the distribution curve generated for each pair of COVID-19 diagnosis (rRT-PCR and Etaware-CDT-2020) for the Chinese patients probed by this research (Figs. 4–7). The distribution pattern of the variables represented on each graph was tending towards

normality, except those generated by Pan et al. [27] for Hubei patients (Fig. 7).

***Note:*** *The link to the data used in this research is provided in Supplementary File "S6".*

## 4. Discussion

The desired model had a perfect correlation between the epidemiological factors (clinical symptoms) and COVID-19 infection status. Variable coherence (i.e., response variable and predictors) was a major factor pertinent for improving model efficiency as described by Etaware et al. [12]. It was observed that the errors of diagnosis or levels of ingenuity of the computer program "Etaware-CDT-2020" was slightly negligible (in some cases) and slightly or totally ambiguous in some situations. The current rapid computer diagnostic model is very flexible, such that it can be updated to accommodate all manner of COVID-19 cases or medical situations related to COVID-19 infection outbreak globally, if new breakthrough emerges in the frontiers of scientific study of the pathogen's relationship with humans and a compilation of an all-inclusive catalogue of symptoms describing the physiological relationship with the primary host (irrespective of the host gender, age, race or colour). The aforementioned observation was in line with the report given by WHO [30,31] who laid emphasis on the ingenuity in the pathogen's physiological relationship with the host organism (Humans) and the level of mutation, adaptation or transformation of viral genome resulting in a major setback in the development of perfect diagnostic tool and a broad-spectrum treatment or clinical therapy for the novel coronavirus 2019 infection.

The level of similarity between the rRT-PCR and Etaware-CDT-2020 COVID-19 diagnoses were indeed very close. This was further affirmed by the normality of the distribution curves generated for the results. The close proximity in the results showed that Etaware-CDT-2020 was indeed an ideal screening tool for COVID-19 infection. This singular achievement is indeed a huge obeisance to the clarion call by the World Health Organization [30], who seek to encourage the sharing of data to better understand and thus manage COVID-19 infection outbreak around the world. The development of more useful screening tools or test kits for early detection of COVID-19 infection is a better countermeasure aimed at curtailing the spread of the disease.

## 5. Conclusion

The close proximity of the results obtained from Etaware-CDT-2020 to that of the real-time reverse transcription polymerase chain reaction (rRT-PCR), is an indication that Etaware-CDT-2020 can be used as a screening tool for early detection of COVID-19 infection, prior to confirmation with rRT-PCR. For now, the program can be easily installed and used at home, in the office, in public and private clinics, isolation centres, hospitals, schools, hotels, clubs, cinemas, Churches, Mosques etc., without restrictions or contravention to religious or ethical or cultural believes.

## 6. Consent to participate

The corresponding author had the sole right to participate or determine the participant in the current study. All data presented in this report was generated from this research.

## 7. Availability of supporting data

All datasets generated or analyzed during the course of this research are included in this article.

## 8. Glossary

Fever: An abnormally high body temperature, usually accompanied by shivering, headache, and in severe cases, delirium [26].
Fatigue (Tiredness): It is an overall feeling of tiredness or lack of energy i.e., it is a complete state of lack of motivation and energy, both physically and mentally [22].
Dry/Chesty Cough: This is a kind of cough that does not bring up any phlegm or mucus. It may cause a tickling sensation due to the feeling of irritation in the throat [35].
Muscular aches and pains (Myalgia): Feeling pain in a muscle or group of muscles [26].
Chill/Shivering: Shaking slightly and uncontrollably as a result of being cold, frightened, or excited [26].
Headache: This can be described as the feeling of pain in one or several parts of the head [19].
Loss of appetite: It is a decrease or lack of desire to eat. It is also known as poor appetite or anorexia [1].
Shortness of breath (Dyspnoea): It is a situation where a person experience difficult or laboured breathing [26].
Sore throat: This is the feeling of pain, scratchiness or irritation in the throat, which is most times worsened when you swallow [24].
Loss of sense of smell: This is medically referred to as anosmia. It is a partial or complete or complete loss of the sense of smell or ability to perceive odours [2].
Loss of sense of taste: This is medically referred to as Ageusia. It is the inability of the tongue to detect sweetness, sourness, bitterness, saltiness, and savoury taste [32].
Nasal congestion: This is a situation where adjacent tissues within the nostrils and blood vessels become swollen with excess fluid, causing a "stuffy" plugged feeling within the nasal cavity [24].
Chest pain: Chest pain appears in many forms, ranging from a sharp stab to a dull ache. Sometimes it feels crushing or burning, in other cases, the pain travels up the neck, into the jaw, and then radiates to the back or down one or both arms. This is usually caused by poor blood flow to the heart and it is medically known to as angina [24,26].
Abdominal pain: This is the feeling of crampy, achy, dull, intermittent or sharp pain in the abdomen [29].
Diarrhoea: A condition in which faeces are discharged from the bowels frequently and in a liquid form [26].
Vomiting or Nausea: A feeling of sickness with the ejection of ingested food matter from the stomach through the mouth [26].
Neurological illness: These are diseases of the central and peripheral nervous system. In other words, the brain, spinal cord, cranial nerves, peripheral nerves, nerve roots, autonomic nervous system, neuromuscular junction, and muscles [33].
Gastrointestinal illness: These are disease that affect any section of the gastrointestinal tract, from the oesophagus to the rectum, and the accessory digestive organs i.e., liver, gall bladder and pancreas [28].
Drowsiness: A feeling of being sleepy and lethargic; sleepiness [26].
Dizziness: This is a term used to describe a range of sensations, such as, feeling faint, woozy, weak or unsteady. In some cases, it creates the false sense that the individual or his/her surrounding is spinning or moving [24].
Stroke: A stroke, also known as cerebrovascular accident (CVA), occurs when the blood supply to part of the brain is interrupted or reduced, preventing brain cells from getting oxygen and nutrients. Brain cells begin to die shortly after [24].

Pneumonia: This is an infection of the lungs caused by fungi, bacteria, or viruses. General symptoms include chest pain, fever, cough etc. [3].
High body temperature: This is an aberration from the normal temperature range of the human body i.e., 36.5 – 37.5°C. an increase in body temperature (above the normal range) is referred to as a high body temperature [32].
Rhinorrhoea (Runny nose): Excess drainage, ranging from a clear fluid to thick mucus, from the nose and nasal passages [32].
Body rash: The word "rash" means a change in the colour and texture of the skin that usually causes an outbreak of red patches or bumps on the skin. It can be defined as a widespread eruption of skin lesions. In common usage of the term, a "rash" can refer to many different skin conditions. A rash can e caused directly or indirectly by a bacterial. viral, or fungal infection [25].
Conjunctivitis: An inflammation of the conjunctiva of the eyes [26].

**Note**: WHO recommend that all patients should be tested for other respiratory diseases using routine laboratory procedures. All patients that meet the suspect-case definition should be tested for COVID-19 virus regardless of whether another respiratory pathogen was found in their specimen sample (WHO, 2020a).

## Ethical approval

Not Applicable

## Author contributions

PME was responsible for data acquisition, mining, curation, organization, analysis, interpretation and presentation of results in a logical manner. The conceptualization, manuscript draft, editing, funding, supervision of research and model development was solely done by PME.

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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bspc.2021.103337.

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