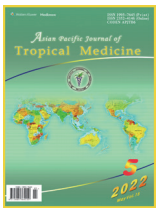

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Pulse oximeter as a home assessment tool: Knowledge and user experience among the community in Malaysia during the COVID-19 pandemic

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ABSTRACT

Objective: To determine the degree of knowledge in the usage of pulse oximeter as a home assessment tool among the community in Malaysia.

Methods: A cross-sectional survey was conducted in November 2021. The questionnaire assessed the knowledge in using pulse oximeters, user experience and opinions in using pulse oximeter as a home assessment tool during the pandemic.

Results: A total of 504 respondents were included in the study, and the mean score in knowledge related to application of pulse oximetry was 73.00%, while the mean score in knowledge related to factors affecting pulse oximetry readings was only 38.51%. A total of 90.5% of the respondents recognised normal pulse rate and 88.5% knew the blood oxygen saturation levels of a healthy adult, while 69.4% recognised the definition of silent hypoxia. In addition, the majority of the respondents agreed that factors such as poor blood circulation (71.2%), excessive movements (69.8%), and hand position (60.7%) affected oximetry readings. However, 61.7%, 81.7%, 77.2% and 76.8% of the respondents could not identify nail polish, skin colour, skin thickness and tattoos as factors that may affect oximetry readings respectively.

Conclusions: The respondents showed a satisfactory level of knowledge related to application of pulse oximetry, but a poor level of knowledge related to factors affecting pulse oximetry readings among the community in Malaysia. Continuous efforts in educating the community on the correct use of pulse oximeters are crucial for appropriate home assessment and avoiding unnecessary stress.

KEYWORDS: COVID-19; Pulse oximetry; SpO_2; Home assessment tool; Silent hypoxia

1. Introduction

The emerging novel coronavirus SARS-CoV-2 is notorious for attacking the respiratory system leading to pneumonia in severe cases. In such cases, gaseous exchange efficiency across the respiratory membranes declines drastically, leading to hypoxia and multiple complicated pathological conditions[1]. Despite oximeter readings of alarming low blood oxygen saturation levels, the patients may not present with dyspnoea or other symptoms of respiratory distress. The presentation of hypoxaemia with no signs of shortness of breath is known as silent hypoxia, the main contributing factor to delayed intervention and ultimately leading to deterioration of COVID-19 manifestations and death[2]. It is believed that the increasing trend of brought-in-dead to emergency departments due to COVID-19 infections could be due to (1) undiagnosed COVID-19, (2) delayed treatment, and (3) poor knowledge in managing COVID-19 patients who are observing home recovery[2].

Daily blood oxygen saturation monitoring in COVID-19 patients has allowed early detection of silent hypoxia, allowing for early intervention for deteriorating COVID-19 patients. Besides arterial

Significance

The degree of knowledge in the usage of pulse oximeter as a home assessment tool was unknown among community dwellers in Malaysia. This survey showed that the mean score in knowledge related to application of pulse oximetry was 73.00%, while the mean score in knowledge related to factors affecting pulse oximetry readings was only 38.51%. Continuous efforts in educating the community in correct use of pulse oximeter are crucial for appropriate medical decision as well as to avoid unnecessary stress.

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blood gas (ABG) analysis, pulse oximetry is also an effective tool for estimating blood oxygen saturation (SpO_2). Pulse oximeter is a standard medical equipment in clinical settings for both screening and monitoring purposes, as it provides non-invasive, portable, fast, accurate, and simple measurement of SpO_2 comparing to ABG analysis. Prior to the COVID-19 pandemic, the use of the pulse oximeter was often limited to clinical settings such as wards, emergency departments, and operation theatres[2]. The pulse oximetry has now gained widespread community usage as a home assessment tool and is a tool highly recommended by World Health Organization (WHO) and many other countries for self-monitoring purposes during this COVID-19 pandemic.

Multiple studies published prior to the COVID-19 pandemic reported that some general practitioners and nurses are not well equipped with sufficient knowledge in applying pulse oximetry in clinical settings[3–6]. With the rapid increase of asymptomatic or mild symptomatic cases who are required to observe mandatory home quarantine, the correct use of a pulse oximeter for early detection of hypoxia has become a crucial in COVID-19 crisis management[7]. The question then arises-what is the knowledge level among the community in the usage of pulse oximetry? Hence, this present study aims to investigate the degree of knowledge in using pulse oximeter as a home assessment tool during this COVID-19 pandemic. In addition, this study also aims to assess the user experience and opinions in utilising a pulse oximeter as a home assessment tool.

2. Subjects and methods

2.1. Study design and setting

This cross-sectional survey was conducted over a 3-week period in November 2021 *via* convenience sampling. This study was approved by Institutional Scientific and Ethical Review Committee (U/SERC/172/2021) and conducted in accordance with the code of ethics.

2.2. Survey instrument

The questionnaire was prepared in English, Bahasa Malaysia, and Chinese (Simplified). The questionnaire was designed in English, forward and backward translation technique was used for the questionnaire preparation in Bahasa Malaysia and Chinese (Simplified). A pilot study with 30 respondents was conducted to test the questionnaire's reliability and validity; the alpha Cronbach values were more than 0.8. All the results from the pilot study were excluded from the actual data analysis.

This questionnaire comprises four sections. The first section was related to sociodemographic profile, the second section was related to knowledge assessment, the third section was related to user experience in using pulse oximeter as a home assessment tool and the fourth section was related to opinions in using pulse oximeter as a home assessment tool. For the knowledge assessment, each correct answer was given one mark, while no mark was given to the incorrect answer. The obtained score was expressed as percentage by using this formula: (Obtained scores/total scores) × 100%.

2.3. Participation eligibility

Eligible participants with age 18 or more than 18-year-old, who reside in Malaysia, understand English, Bahasa Malaysia or Chinese (Simplified) were invited for survey participation.

2.4. Survey invitation and informed consent

Personal invitations consisted of the survey poster and questionnaire hyperlink were sent to personal contacts *via* E-mails, Short Message Text, and mobile messenger apps. The same invitation was also posted to various social media platforms to call for public participation. All the participants were asked to provide informed consent before proceeding to the questionnaire. The participants can withdraw from the study by stopping answering the questions.

2.5. Data analysis

The statistical analysis was performed using Statistical Package for Social Science (SPSS) version 22.0. Categorical data were expressed as frequency and percentage, while continuous data were checked with the normality test and Levene's test, and then continuous data with confirmed normal distribution were expressed as mean and standard deviation (mean±SD). Univariate analysis was performed using independent *t*-test for 2-group comparison, One-way ANOVA followed by Tukey *post-hoc* test for multiple comparisons. Multivariate analysis was performed using MANOVA. A *P*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Sociodemographic characteristics

A total of 506 respondents participated in this survey, while two respondents were excluded from the study as they did not meet the inclusion criteria; therefore, 504 respondents were included for data analysis. Out of 504 respondents, 40.9% (206/504), 26.4% (133/504), 28.2% (142/504), and 4.6% (23/504) were from the age groups of 18-25, 26-29, 40-59 and >60 years old, respectively; while 61.1% (308/504) and 38.9% (196/504) of the respondents were female and male, respectively. A total of 58.7% (204/504) of the respondents were married, while 40.5% (296/504) of the respondents were single. In addition, 13.1% (66/504) of the respondents were secondary school leavers, 23.6% (119/504), 51.8% (261/504)

and 10.9% (55/504) were pre-university, tertiary and post-tertiary education degree holders. A total of the 58.7% (296/504) of the respondents were pulse oximeter users, and 49.6% (250/504) had undergone COVID-19 diagnosis tests/suspected for COVID-19.

3.2. Score in knowledge related to the application of pulse oximetry and factors affecting pulse oximetry readings

About 90% of the respondents recognised the normal pulse rate and blood oxygen saturation levels of a healthy adult, while 70% recognised the definition of silent hypoxia. A total of 81.3% and 40.9% of the respondents agreed that a pulse oximeter is useful in detecting silent hypoxia and deterioration of COVID-19. Up to 90.5% of the respondents agreed that it is essential to source a pulse oximeter approved by authority bodies, and 74.2% of the respondents agreed that they should seek medical attention immediately when their SpO_2 is less than 94% (Table 1).

Table 1. Knowledge related to application of pulse oximetry.

Knowledge of pulse oximeter	*n* (%)
What does the pulse oximeter measure?	
The blood oxygen saturation (SpO_2) and pulse rate	420 (83.3)
Pulse rate only	0 (0.0)
SpO_2 only	29 (5.8)
Blood pressure	2 (0.4)
Carbon dioxide saturation in blood	0 (0.0)
I don't know	53 (10.5)
What is the role of using pulse oximeters in COVID-19 patient?	
Early detection of silent hypoxia / happy hypoxia	410 (81.3)
Early detection of deterioration of COVID-19	206 (40.9)
To diagnose COVID-19	38 (7.5)
To treat COVID-19	4 (0.8)
I don't know	40 (7.9)
What is the normal pulse rate of a healthy adult?	
Less than 50 beats per minute	5 (1.0)
60-100 beats per minute	455 (90.3)
200-300 beats per minute	2 (0.4)
I don't know	42 (8.3)
What is the normal blood oxygen level of a healthy adult?	
95%-100%	446 (88.5)
85%-94%	16 (3.2)
70%-84%	3 (0.6)
Less than 70%	39 (7.7)
I don't know	0 (0.0)
It is important to get a medical device authority Malaysia approved pulse oximeter.	
Yes	456 (90.5)
No	14 (2.8)
I don't know	34 (6.7)
Silent hypoxia/happy hypoxia is a condition of	
Low SpO_2 without breathing difficulties	350 (69.4)
Low SpO_2 with breathing difficulties	89 (17.7)
Hypoxia due to excessive happiness	4 (0.8)
I don't know	61 (12.1)
What should you do if your SpO_2 is less than 94%?	
Seek for medical attention immediately	374 (74.2)
Rest and re-test	265 (52.6)
Take over-the-counter medicine / supplement / herbs	10 (2.0)
Get supplementary oxygen without medical consultation	11 (2.2)
It is nothing should be worried about	6 (1.2)
I don't know	35 (6.9)

Concerning the knowledge related to factors affecting pulse oximetry readings, the majority of the respondents agreed that factors such as poor blood circulation, excessive movements, and hand position affect oximetry readings. However, more than two-thirds of the respondents could not identify nail polish, skin colour and thickness, and tattoos as factors that may affect oximetry readings. In addition, about half of the respondents recognised asthma and chronic smoking could affect pulse oximetry readings, while merely 21.2% aware that anaemia does not affect pulse oximetry readings (Table 2).

Table 2. Knowledge related to factors affecting pulse oximetry readings.

Which of the following factors affect oximetry readings?	*n* (%)
Time to rest before using a pulse oximeter	
5 minutes	297 (58.9)
1 hour	36 (7.1)
No resting required	40 (7.9)
I don't know	131 (26.0)
Nail polish	
Yes	193 (38.3)
No	194 (38.5)
I don't know	117 (23.2)
Skin colour	
Yes	92 (18.3)
No	309 (61.3)
I don't know	103 (20.4)
Skin thickness	
Yes	115 (22.8)
No	276 (54.8)
I don't know	113 (22.4)
Henna/tattoo	
Yes	117 (23.2)
No	266 (52.8)
I don't know	121 (24.0)
Excessive movement	
Yes	352 (69.8)
No	67 (13.3)
I don't know	85 (16.9)
Hand position	
Yes	306 (60.7)
No	107 (21.2)
I don't know	91 (18.1)
Cold fingers/extremities	
Yes	271 (53.8)
No	130 (25.8)
I don't know	103 (20.4)
Poor blood circulation	
Yes	359 (71.2)
No	52 (10.3)
I don't know	93 (18.5)
Anaemia	
Yes	277 (55.0)
No	107 (21.2)
I don't know	120 (23.8)
Asthma	
Yes	273 (54.2)
No	121 (24.0)
I don't know	110 (21.8)
Chronic smoking	
Yes	248 (49.2)
No	136 (27.0)
I don't know	120 (23.8)

The mean score related to knowledge in the application of pulse oximetry was (73.00±19.98)%, while the mean score related to knowledge in factors affecting pulse oximetry readings was (38.51±22.67)% (Table 3).

Table 3. Mean score in knowledge related to pulse oximetry.

Score	Mean±SD (%)
Knowledge score related to the application of pulse oximetry (A)	73.00±19.98
Knowledge score related to factors affecting pulse oximetry readings (B)	38.51±22.67
Mean score (A+B)/2	55.76±21.33

Each correct answer was given a score of 1 while incorrect answer was given a score of 0. The total mark was expressed as percentage.

3.3. Sociodemographic characteristics and its association with the average score in knowledge related to pulse oximetry

Univariate analysis showed that the younger age group, single marital status, female, higher educational level, healthcare related profession, user experience, people who were suspected of COVID-19 and had undergone COVID-19 test have higher knowledge scores than their counterparts. While location-based on COVID daily cases and history of COVID-19 were not associated with the knowledge levels (Table 4). Multivariate analysis showed there was no interaction effects between dependent variables in affecting the participants' knowledge levels related to pulse oximetry were found.

3.4. User experience and opinions in using pulse oximeter as a home assessment tool

A total of 64.5% of the pulse oximeter users owned the device to standby for emergency use, while 25.7% used pulse oximeters to monitor COVID-19 patients and close contacts under mandatory home quarantine. On the other hand, 26.0% of them used the device to monitor their health conditions other than COVID-19, and more than half of them used the device at least twice a week. A total of 64.5% of the pulse oximeter owner procured the device *via* online stores, while 75.7% of the pulse oximeter users acquired the techniques in using pulse oximeter *via* product user manuals/official infographics published by the government agencies (Table 5). As high as 82.3% of the respondents promoted pulse oximetry to monitor COVID-19 patients under home quarantine, and 68.8% of them supported that patients who had recovered from COVID-19 should continue monitoring their SPO_2 for another three months. Up to 80.0% of them agreed that it is crucial to detect early COVID-19 deterioration and silent hypoxia. At the same time, 70.4% of the respondents think that every household should have a pulse oximeter for self-monitoring purposes. On the other hand, 33.5% of the respondents believe that smartphones and wearable technology are accurate for the clinical measurement of blood oxygen saturation levels (Table 6).

Table 4. Sociodemographic factor and its association with the mean score in knowledge related to pulse oximetry.

Items	*n*	Mean±SD (%)
Age group		
18-25 years old	206	59.71±22.10
26-39 years old	133	$52.67±22.14^{A}$
40-59 years old	142	$51.37±18.59^{A}$
60 years old and above	23	$49.48±19.66^{A}$
Sex		
Female	308	$57.17±20.53^{**}$
Male	196	51.68±22.26
Marital status		
Single	296	57.43±22.54
Married	204	$51.33±19.14^{Bb}$
Others	4	66.67±11.66
Educational level		
Primary education	3	47.62±28.96
Secondary	66	43.79±21.28
Pre-Uni	119	$58.50±19.85^{Cc}$
Tertiary	261	$56.29±20.84^{Cc}$
Post-tertiary	55	$55.50±22.47^{Cc}$
Health care-related profession		
Yes	184	$65.42±18.52^{***}$
No	320	49.06±20.55
Pulse oximeter user		
Yes	296	$59.76±18.24^{***}$
No	208	48.31±23.65
Undergone COVID-19 test		
Yes	250	$57.22±21.19^{*}$
No	254	52.89±21.52
COVID-19 positive history		
Yes	17	48.18±24.99
No	487	55.28±21.19
Location based on COVID situation		
Phase 1 (daily cases >4 000 during survey period)	334	55.69±21.20
Phase 2 (daily cases <4 000 during survey period	129	52.64±22.60
Phase 3 (daily cases <2 000 during the survey period)	41	57.26±17.74

Data were analysed using One-way ANOVA followed by *post-hoc* Tukey test for multiple groups comparison, and independent *t*-test for 2-group comparison. $^{*}P<0.05$, $^{**}P<0.01$, $^{***}P<0.001$ compared to its counterpart. $^{A}P<0.01$ compared to 18-25 years old, $^{B}P<0.01$ compared to single, and $^{b}P<0.01$ compared to others, $^{C}P<0.05$ compared to primary and $^{c}P<0.05$ compared to secondary education.

4. Discussion

Prior to COVID-19 pandemic, fingertip pulse oximetry is only commonly used in clinical settings such as the emergency departments, wards, and operational theatres for quick screening and monitoring of SpO_2 levels in patients. The usage of pulse oximeter in outpatient clinics and non-clinical settings was still uncommon. The general knowledge among healthcare providers in using finger pulse oximetry has been assessed in several countries in the past decades. Multiple studies done in India, Hong Kong (China), Sunderland and United Kingdom have indicated insufficient knowledge on the use of pulse oximetry among their healthcare professionals[3,4,8-10].

Another study revealed that the majority of the general practitioners in South Australia did not use pulse oximetry to assess the general health of their patients[5].

Table 5. User experience in using pulse oximeter as a home assessment tool.

Items	Response, *n* (%)
Own a pulse oximeter (*n*=504)	
Yes	296 (58.7)
No	208 (41.3)
If no, willingness to get a pulse oximeter in the future (*n*=208)	
Yes	48 (23.1)
Maybe	126 (60.6)
No	34 (16.3)
Reason in owing pulse oximeter (*n*=296)	
To monitor COVID-19 positive individual under mandatory home quarantine	39 (13.2)
To monitor COVID-19 close contacts under mandatory home quarantine	37 (12.5)
To monitor the health condition other than COVID-19 (*e.g.* asthma, respiratory problems)	77 (26.0)
To standby for emergency use in this COVID-19 pandemic	191 (64.5)
Influenced by news, social media (friends/newspaper/website) on the uses of pulse oximeter	81 (27.4)
To ease anxiety and fear of COVID-19 infection	80 (27.0)
Frequency in using pulse oximeter (*n*=296)	
1 time or above a day	78 (26.4)
Less than 3 times a week	78 (26.4)
Less than 1 time a week	40 (13.5)
When I feel not well	83 (28.0)
I do not use it since the day of owning	17 (5.7)
Pulse oximeter procurement time (*n*=296)	
Before March 2020	15 (5.1)
March-December 2020	12 (4.1)
January-November 2021	248 (83.8)
Not able to recall	21 (7.0)
Source of procurement (*n*=296)	
Online stores	191 (64.5)
Physical stores	99 (33.4)
Others *i.e.* gifts	6 (2.0)
Knowledge acquisition in using a pulse oximeter (*n*=296)	
Yes	246 (83.1)
No	50 (16.9)
Sources in acquiring techniques in using a pulse oximeter (*n*=296)	
Product user manual/flyers/infographic published by Ministry of Health, Malaysia	224 (75.7)
Retail pharmacists/doctors/healthcare workers/suppliers	75 (25.3)
Random online resources	85 (28.7)
Family/relatives/friends	36 (12.2)
Formal lecture	3 (1.0)
Did not learn	11 (3.7)
Demonstration in using a pulse oximeter by supplier/seller (*n*=296)	
Yes	148 (50.0)
No	148 (50.0)
Explanation in interpreting readings in pulse oximeter by supplier/seller (*n*=296)	
Yes	126 (42.6)
No	170 (57.4)

Table 6. Opinions in using pulse oximeter as a home assessment tool.

Items	Response, *n* (%)
Opinions with a "yes" answer	
Smartphone technology, wearable devices technology is accurate for the clinical measurement of blood oxygen saturation level	169 (33.5)
I strongly promote the use of pulse oximetry to monitor COVID-19 patients quarantined at home	415 (82.3)
Pulse oximetry is very important to detect early COVID-19 deterioration	403 (80.0)
Pulse oximetry can detect hypoxia associated with acute COVID-19	415 (82.3)
Every household should have a pulse oximeter for self-monitoring purposes	355 (70.4)
Who do you think should use a pulse oximeter for home monitoring purpose?	
Normal healthy persons	250 (49.6)
Someone presents with flu symptoms (fever, chills, cough, sore throat, headaches, runny nose, tiredness *etc.*)	346 (68.7)
Patients with respiratory problems (asthma, tuberculosis *etc.*)	390 (77.4)
COVID-19 patients who are under the mandatory home quarantine	429 (85.1)
Close contacts of COVID-19 patients	374 (74.2)
COVID-19 post-recovery monitoring for 3 months	347 (68.8)
COVID-19 post-recovery monitoring for 6 months	245 (48.6)

The emergence of COVID-19 has highlighted the importance of accessing SpO_2 levels in outpatient clinics and even as a home assessment tool for self-monitoring among COVID-19 patients observing home quarantine[7]. This present survey discovered that merely 5.1% of the respondents owned a pulse oximeter before the pandemic, while 4.1% of the respondents owned a pulse oximeter in the first year of the pandemic (March-December 2020), up to 83.8% of the respondents equipped their household with a pulse oximeter in year 2021. It is crucial for the home users to understand the basic principles and concepts on how the pulse oximeter works, as well as its limitation in estimating SpO_2 levels. Indeed, erroneous readings, either falsely lower or higher SpO_2 readings certainly lead to unnecessary stress or delayed medical consultation.

This study revealed that the knowledge related to the application of pulse oximetry in the Malaysia community is at a satisfactory level of (55.76±21.33)%, while the knowledge related to factors affecting pulse oximetry readings is at the worrying stage. The majority of the respondents recognised normal ranges of heart rate and SpO_2 levels, and they were aware the actions should be taken, for example, seeking immediate medical attention while their SpO_2 is less than 94%. Unfortunately, the knowledge in recognising factors affecting pulse oximetry readings was disappointing. The majority of the respondents were not aware that skin colour, skin thickness and presence of tattoos affect pulse oximetry readings. In fact, darker skin colour, thick skin, presence of henna or tattoo and nail polish often produces lower SPO_2 readings[7]. These misconceptions undoubtedly lead to inappropriate medical decision and unnecessary stress.

This survey focused on technical factors affecting pulse oximetry readings rather than its clinical applications among patients with more complicated medical conditions. Knowledge in clinical factors that cause falsely low, normal or elevated SPO_2, *e.g.* carbon monoxide poisoning, intravenous pigmented dyes, methehaemoglobinaemia, sulfhemoglobinaemia, severe hyperbilirubinaemia, sepsis, foetal Hb were not assessed in this study. Anaemia, asthma, and poor circulation are the three clinical conditions that have been included in this study. More than half of the respondents agreed that asthma and poor circulation affect SpO_2 readings, while merely 20% of the respondents knew that anaemia does not affect SpO_2 readings. The accuracy of pulse oximetry in monitoring blood oxygenation in anaemic patients has been discussed extensively. In general, anaemia per se does not affect SpO_2 readings in normoxic individuals. It has been reported that patients with severe anaemia and concomitant hypoxemia can spuriously affect SpO_2 readings[11].

This study uncovered that approximately 3 out of 10 respondents believed that smartphones and wearable devices technology are accurate for the clinical measurement of SpO_2 levels. Numerous scientific reports have shown that many novel wearable devices or smartphone application-based did not meet the predefined accuracy standards for SpO_2 measurement and other vital signs. They have concluded that these devices/applications did not provide any clinically meaningful data[12]. Overdependent on these non-medical gadgets leads to erroneous healthcare decisions and delayed diagnosis. A single, non-replicated study had reported that Apple Watch 6 is reliable in obtaining heart rate and SpO_2 in patients with lung diseases in a controlled environment[12]. It is worth pointing out that the SpO_2 of these patients was measured by healthcare providers under a controlled clinical setting, and the usage of the wearable does not translate directly as a reliable medical home assessment tool for accurate oxygen saturation levels.

Almost two-thirds of the respondents procured their pulse oximeter *via* online stores and 50% of the pulse oximeter suppliers did not demonstrate the correct techniques in using pulse oximeter. The primary source of acquiring techniques in using pulse oximeter was self-learning via the product user manual, infographics published by the government agency and random web-based information without learning verification by a trusted third party. Barely 25.3% of the respondents acquire such techniques from reliable resources such as retail pharmacists, doctors, or healthcare providers. These could contribute to the low degree of knowledge on the factors affecting pulse oximeter readings assessed in this survey.

More than 70% of the respondents agreed that every household should have a pulse oximeter for self-monitoring purpose and most respondents (>80%) promote the use of pulse oximeter to monitor COVID-19 patients observing home quarantine. The same respondents agreed that pulse oximetry is important in the early detection of hypoxia and COVID-19 deterioration. More than two-thirds of the respondents agreed that those with flu-like symptoms, or respiratory problems, close contacts of COVID-19 patients, COVID-19 patients, and patients who have recovered from COVID-19 in less than three months should use a pulse oximeter for continuous home monitoring purpose. Approximately half of the respondents agreed that normal healthy persons should also monitor their heart rate and SpO_2 levels. These favourable responses reflect a positive attitude towards the uses of pulse oximeter as a life-saver self-monitoring tool in this COVID-19 pandemic.

Convenience sampling *via* online survey used in this study is beneficial as it can be quickly disseminated within a short period with lesser administrative costs. However, it may generate potential sampling bias and possesses the possibility of under- or over-representation of the population. Moreover, the limitation of this study was the sociodemographic compositions are dissimilar to those in Malaysia and the findings of this study may not be able to be generalised to the entire population in Malaysia. The low response rate among the elderly (60 and above years old) may be due to (1) lack of Internet accessibility, (2) inactive in using social media, E-mails, messenger apps, (3) lack of knowledge or accessibility in using smartphones, laptops and online tools. Furthermore, the lack of significant findings shown in MANOVA could be due to the limitation of the sample size of this present study. A larger sample size with more comprehensive distribution coverage alongside random sampling, is required to further assess the dependent factors affecting the knowledge levels related to pulse oximetry.

In conclusion, the degree of knowledge in using pulse oximeters is merely at the average level of (55.76±21.33)% among the local community in Malaysia. Therefore, continuous efforts in educating the local community on the correct use of fingertips pulse oximeter and identifying the common factors that may lead to erroneous readings are essential. Educational campaigns *via* school activities, public health campaigns, roadshows are the essential channels to deliver the messages. Future studies should investigate the efficacy of these campaigns in increasing the knowledge levels of the usage of the pulse oximeter to provide a clearer picture of the effectiveness of the mentioned measures.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Authors' contributions

LSK, MJW, CKY, CYS, HWY, ROCY, TWC, CAL developed the theoretical formalism, performed the analytic calculations and performed the numerical simulations. LSK and CAL contributed to the final version of the manuscript. LSK supervised the project.

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