ORIGINAL ARTICLE

Basic Working Knowledge of Pulse Oximetry among Healthcare Workers and Patients Requiring Oxygen Therapy in a Tertiary Care Center in North India

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Abstract

Introduction: Use of pulse oximetry devices (PODs) by healthcare workers and the general population is becoming popular, especially after coronavirus disease 2019 (COVID-19) pandemic. Use of PODs has several limitations that may lead to inaccurate readings. Hence, we planned to do a study to assess the basic working knowledge of pulse oximetry among healthcare workers and patients.

Materials and methods: This was a cross-sectional descriptive study conducted among the healthcare workers and patients requiring oxygen therapy admitted to MM Medical College & Hospital, Kumarhatti-Solan. Total duration of the study was 6 months from January to June 2023. A validated previously published semi-structured simplified questionnaire containing a total of 20 questions was used to assess the knowledge of pulse oximetry among the study population. The collected data were entered into Statistical Package for the Social Sciences (SPSS) version 20 for analysis.

Results: Out of 290 participants in this study, 89 (30.7%) were nurses, 76 (26.2%) were doctors, 73 were (25.2%) medical students, and 52 (17.9%) were patients. Majority, 189 (68.3%), of the participants had poor knowledge of pulse oximetry. Lack of formal training of pulse oximetry was associated with poor knowledge of pulse oximetry among healthcare workers (p-value < 0.001). Lower level of education status and socioeconomic status were negatively correlated with patients' basic working knowledge of pulse oximetry.

Conclusion: Our study noted poor basic working knowledge of pulse oximetry among healthcare workers and patients requiring home oxygen therapy. There is an utmost need of pulse oximetry training for healthcare professionals and patients to ensure quality care for patients.

Keywords: Healthcare workers, Knowledge, Oxygen therapy, Patients, Pulse oximetry.

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Introduction

Pulse oximetry is an omnipresent and noninvasive means of assessing oxygen saturation. Pulse oximetry devices (PODs) use is increasing among healthcare workers and general population, especially after the coronavirus disease 2019 (COVID-19) pandemic.[1] However, pulse oximetry only provides the rough assessment of percentage of hemoglobin saturation with oxygen in most cases. Also, the accuracy of oxygen saturation (SpO_2) reading of POD when compared to the oxygen saturation in arterial blood (SaO_2) reading is highest in the range of 70–100%.[2] In the current era, SpO_2 is defined as the "fifth vital" sign.[3] In the early 1970s, pulse oximetry was first developed in Japan.[4] Currently available POD are incorporated with two light-emitting diodes (LEDs) that emit the red (660 nm) and infrared (940 nm) wavelengths. On passing the light *via* a well-perfused part of the body, deference in absorbance of specific wavelengths of light and the oxyhemoglobin/deoxyhemoglobin ratio is detected by the inbuilt algorithm of POD. This calculated result is depicted as the percentage of SpO_2 in POD.[5]

Pulse oximetry devices (PODs) have various shortcomings which may lead to false readings. Pulse oximetry may give incorrect readings in various clinical situations including ambient lightning, low perfusions, nail polish, during motion, arrhythmias, and methemoglobinemia.[2,5,6] Other factors that can confound the results include pH, temperature, and quality of POD.[6] Unawareness about such limitation of POD among the health workers and the patients can be misleading and result in inappropriate decision-making compromising patient safety.[3]

There is limited data on the basic working knowledge of POD in healthcare workers and patients requiring oxygen therapy in the Indian population. Most of the previous studies are limited by their use of small sample sizes and convenience sampling techniques. Hence, we planned this study to evaluate the basic working knowledge of pulse oximetry among the healthcare workers and patients prescribed oxygen therapy in a tertiary care center in North India.

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Materials and Methods

This was a cross-sectional descriptive study conducted among the healthcare workers and patients prescribed with oxygen therapy admitted in the department of respiratory medicine, at MM Medical College & Hospital, Kumarhatti-Solan, Himachal Pradesh, a tertiary care center of North India after taking Institutional Ethics Committee approval.

Total duration of the study was 6 months from January to June 2023. Aim of the study was to assess the basic working knowledge of pulse oximetry among healthcare workers and patients requiring oxygen therapy in a tertiary care center in North India.

Only the participants above 18 years, patients requiring oxygen therapy, and willing to participate were included in the study. Patients not requiring oxygen therapy and critically ill were excluded from the study.

Sample Size Calculation

The sample size was calculated as 284, assuming a frequency of the outcome factor in the population (p) of 50 ± 5, a 95% confidence level, an acceptable difference of 5% ($d = 0.05$), and a design effect of 1. Hence, we included a total of 290 participants in this study.

Data Collection and Analysis

The participants who had given consent for study and fulfilled inclusion and exclusion criteria were inducted consecutively as study population. Baseline demographic characteristics including education status of the participants were recorded. Each participant was interviewed in person employing a semi-structured simplified questionnaire acquired from previously published study.[7] The questionnaire comprises the basic principle, mechanisms, and technicalities of pulse oximetry. Also, common errors of result interpretation including various factors affecting the accuracy of measurements and limitations of POD were covered in the questionnaire. Based on these topics, 20 questions of the "yes/no" type were formulated. Score of 1 was given for each correct answer and score of 0 for each incorrect response. The final score was calculated at the end of interview (out of 20). A correct answer of >16 out of 20 questions, that is, >80% was considered good knowledge, while a correct response of ≤16 (≤80%) was considered poor knowledge. Subjects were further divided into two groups—group I, Healthcare workers, including doctors, nurses, medical students, and interns; and group II, patients requiring oxygen therapy.

Data Processing and Analysis

The data were collected at the end of study and were entered into Statistical Package for the Social Sciences (SPSS) version 20 for descriptive analysis. Mean ± standard deviation (SD) was used for depicting continuous variables and count and percentage were used to depict the categorical variables. Student's *t*-test was used for group analysis based on education level, and socioeconomic status. Chi-squared test was used to calculate significance levels for categorical data and *t*-test was utilized for the comparison of continuous data. The *p*-value of <0.05 was assumed significant.

Results

Out of 290 participants in this study, 89 (30.7%) were nurses, 76 (26.2%) were doctors, 73 (25.2%) were medical students, and 52 (17.9%) were patients prescribed oxygen therapy. The median age was 36.5 ± 32 [interquartile range (IQR)] years while 166 (57.2%) were female and 124 (42.7%) male. Overall score (mean ± SD) of basic working knowledge of pulse oximetry among participants was 8.22 ± 5.9. Demographic profiles of subjects are given in Table 1. Out of all, 93 (32%) had completed graduation, and 86 (29.6%) had high school education, followed by elementary education in 61 (21%) participants (Table 1). Majority, 72 (24.8%), of participants belong to upper middle-class families followed by upper lower 60 (21%) and lower middle class 59 (20.3%). Out of all, most, 189 (68.3%), of the participants were having poor basic working knowledge of pulse oximetry. Knowledge of pulse oximetry among the participants in different groups is shown in (Figure 1). Lower level of education status and lower level of modified Kuppuswamy socioeconomic status had statistically significant association with poor basic working knowledge of pulse oximetry among the patients, $p = 0.0213$ and $p = 0.0143$, respectively (Table 1). Only a few healthcare workers, that is, 63 (21.7%) had received formal training in the form of lectures/hands-on equipment training. Lack of formal training of pulse oximetry was associated with poor

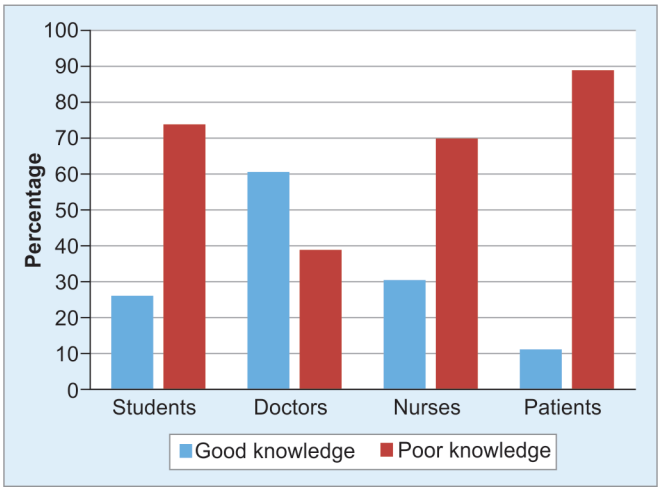

Fig. 1: Knowledge of pulse oximetry among the participants in different groups

Table 1: Demographic profiles of subjects

Characteristics		*N = 290 n (%)*	*p-value*[§]
Age (year)	18–34	118 (40.6)	0.6903
	35–44	83 (28.6)	
	45–60	49 (16.8)	
	>60	40 (13.7)	
Gender	Male	124 (42.7)	0.5213
	Female	166 (57.2)	
Education level	No formal education	18 (6.2)	0.0213*
	Elementary education	61 (21)	
	High school education	86 (29.6)	
	Graduate	93 (32)	
	Postgraduate	32 (11)	
Socioeconomic status	Upper class	53 (18.2)	0.0143*
	Upper middle class	72 (24.8)	
	Lower middle class	59 (20.3)	
	Upper lower	60 (21)	
	Lower	46 (15.9)	

[§], association between demographic variables and poor knowledge of pulse oximetry; *, significant value ($p < 0.05$)

knowledge of pulse oximetry among healthcare workers (p-value < 0.001). Responses of participants regarding knowledge of pulse oximetry are depicted in Table 2. Only 126 (43.4%) participants knew that pulse oximetry was accurate for oxygen saturation between 70 and 100% (43.4). Majority, 171 (58.9%), of participants were not aware of the fact that a change in body position or ambient light can affect pulse oximetry readings.

Discussion

This descriptive study was conducted among the health care workers and patients requiring oxygen therapy. Majority (30.7%) of participants in this study were nurses, followed by doctors (26.2%), medical students (25.2%), and patients (17.9%) requiring oxygen therapy. The median age was 36.5 ± 32 (IQR) years and 57.2% were female and 42.7% were male. Most (68.3%) of the participants in the study demonstrated poor knowledge of pulse oximetry among both healthcare workers and patients requiring oxygen therapy. Alarmingly, 39.5% of doctors were also lacking an adequate knowledge of pulse oximetry and its interpretation. Several previous studies in the literature also showed significant deficits in knowledge of pulse oximetry amongst nurses, doctors, and other healthcare workers.[8] Most of the previous studies were found to have small

Table 2: Knowledge of pulse oximetry among the participants

S. No.	*Questions*		*Response n (%)*
1	Pulse oximetry has been found to be accurate for oxygen saturation between 70 and 100%	Yes	126 (43.4)
		No	164 (56.6)
2	Pulse oximetry is used for rapid detection of tissue hypoxia	Yes	239 (82.4)
		No	51 (17.6)
3	Clinical assessment alone has been shown to be as effective as pulse oximetry monitoring in the detection of hypoxemia	Yes	62 (21.4)
		No	228 (78.6)
4	Pulse oximetry may be unreliable in severely anemic patients	Yes	116 (40)
		No	174 (60)
5	During vasoconstriction, sensor placement on fingernail provides more accurate reading than its placement on central sites (ear, nose)	Yes	166 (57.2)
		No	124 (42.8)
6	Colored nail polish and synthetic nails do not affect the accuracy of pulse oximetry readings	Yes	159 (54.8)
		No	131 (45.2)
7	Pulse oximetry readings are less accurate when the patient is moving	Yes	122 (42)
		No	168 (58)
8	An oxygen saturation value of 90% provided by pulse oximetry corresponds to a partial oxygen pressure in arterial blood of 90 mm Hg	Yes	156 (53.8)
		No	134 (46.2)
9	Oxygen saturation values provided by pulse oximetry are equally accurate to those provided by the analysis of arterial blood gasses	Yes	173 (59.6)
		No	117 (40.4)
10	Accurate pulse oximetry readings are more difficult to obtain when peripheral perfusion is poor	Yes	131 (45.1)
		No	159 (54.9)
11	Pulse oximetry readings are usually not affected by body position or ambient light	Yes	171 (58.9)
		No	119 (41.1)
12	Patients are at increased risk for desaturation during invasive procedures	Yes	158 (54.5)
		No	136 (46.5)
13	Pulse oximetry is not an indicator of adequacy of ventilation	Yes	170 (58.6)
		No	120 (41.4)
14	Pulse oximetry provides real time readings when the sensor is placed on the fingernail	Yes	170 (58.6)
		No	120 (41.4)
15	Use of pulse oximetry is strongly recommended during cardiopulmonary resuscitation	Yes	168 (57.9)
		No	122 (42)
16	Use of pulse oximetry is strongly recommended when the patient is on supplemental oxygen	Yes	212 (73.1)
		No	78 (26.9)
17	The majority of pulse oximetry alarms are correct	Yes	195 (67.2)
		No	95 (32.8)
18	Conventional pulse oximetry is based on the absorption of red and infrared light by blood	Yes	138 (47.6)
		No	152 (52.6)
19	Pulse oximetry sensor is highly sensitive to mechanical damage	Yes	189 (65.2)
		No	101 (34.8)
20	Pulse oximetry readings are not affected by smoke inhalation	Yes	155 (53.4)
		No	135 (46.6)

sample sizes and they included healthcare professionals. However, we included patients who require home oxygen therapy which might provide an added advantage in their treatment compliance and better understanding of disease conditions.

In our study, lower levels of education status and lower levels of modified Kuppuswamy socioeconomic status had having statistically significant association with poor basic working knowledge of pulse oximetry among the patients, $p = 0.0213$ and $p = 0.0143$, respectively. Similarly, a study done by Seeley et al.[9] demonstrated that a lower level of education was negatively correlated with knowledge of pulse oximetry. Lower levels of socioeconomic status having poor purchasing power of POD and lack of awareness regarding pulse oximetry can be one of the reasons for poor knowledge of pulse oximetry among them. Mean final score out of 20 questions in our study participants was 8.22. However, the mean final score in the study done by Kiekkas et al.[10] was 12.8 out of 20. Another recent study reported a mean final score of 12 out of 22 questions among the study participants.[11] These values are a little higher than those seen in our study. This difference in scores might be due to inclusion of patients in the present study who have poor basic working knowledge of pulse oximetry compared to healthcare professionals.

In our study, only a few (21.7%) healthcare workers had received formal training in the form of lectures/hands-on equipment training. Lack of formal training in pulse oximetry was associated with poor knowledge of pulse oximetry among healthcare workers (p-value < 0.001). Similar results were seen by Faponle et al.[12] where 28% were trained in pulse oximetry interpretation. In another study, 43% of the participants believed that lack or inadequate training in pulse oximetry interpretation was a common reason for poor knowledge.[12,13]

Various previous studies showed that healthcare professionals who worked in intensive care units (ICU) or emergency departments had better knowledge of pulse oximetry interpretation compared to others.[8,10]

On the contrary, this was not true in other studies, where experienced nurses, consultants, and healthcare professionals who had an average of >12 years of experience in the ICU had shown poor knowledge of pulse oximetry.[12,14,15] These varying results might be explained by the fact that correct use and interpretation of pulse oximetry requires adequate training about the basic principle, physiology, and knowledge of factors that can affect the results of pulse oximetry and its limitations.

In the present study, the majority, 171 (58.9%), of participants were not aware of the fact that change in body position or ambient light can affect pulse oximetry readings. Similar deficiencies in the knowledge of the principles of pulse oximetry have been demonstrated by many studies in the past.[10,15,16] Regular changes in body position or excessive body movements including tremor or convulsions cause falsely low SpO_2. Similarly, high-intensity lighting can dilute the infrared rays which can lead to an incorrect reading by sensor in PODs. Therefore, a bright lighting environment should be avoided while monitoring the SpO_2 using PODs.[6,10,15]

Most (around 50% of participants) participants in these studies reported poor awareness among healthcare workers of the fact that the adequacy of ventilation including respiratory effort, respiratory failure, labored breathing, and blood CO_2 levels are not measured by pulse oximeters. This knowledge was also poor in our study participants (41.4%). An almost similar result was reported in a recent survey where 40% of participants had poor knowledge of the same question.[11]

In contrast to previous studies, our study participants also included patients, who expecting less knowledge of PODs among them. Interestingly, in our study, 82.4% of participants (68% healthcare professionals) were unaware of the fact that pulse oximetry does not measure tissue hypoxia. This suggests a lack of adequate knowledge of the two different terminologies, "hypoxia" and "hypoxemia" amongst healthcare professionals. Similar result was noted by Milutinović et al.[11]

Various studies have shown that there is marked variability in healthcare professionals about the correct knowledge of the use or interpretation of pulse oximetry. This may contribute to misleading diagnoses and patient morbidity. Hence, regular training sessions regarding the proper use of pulse oximetry should be given to all healthcare workers. All patients requiring home oxygen therapy should be made aware of the basic working knowledge of pulse oximetry. Our study has some limitations such as, there were very few questions in our study as compared to other previous studies, a sample size of the study was small and this was only a single-center study. Future research is needed with larger sample sizes of the study population from multiple centers for more generalized results.

Conclusion

The results of the present study showed that there is poor knowledge and understanding of PODs and their interpretation in the patients requiring home oxygen therapy as well as in healthcare workers looking after them. Lower educational and socioeconomic status were negatively associated with basic working knowledge of pulse oximetry among patients. Lack of formal training in pulse oximetry was associated with poor knowledge of pulse oximetry among healthcare workers. PODs have several limitations which may lead to inaccurate readings. Emphasis needs to be given to regular formal training in pulse oximetry to ensure quality care for patients requiring oxygen therapy.

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