Oxygen saturation changes in relation to the use of gloves: an uncontrolled before and after intervention study

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Research Article

Keywords: COVID-19, gloves, pulse oximetry, oxygen saturation.

Posted Date: March 12th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-275983/v1

Abstract

Background: Nurses have had an essential role in health promotion (hand washing, social distance and wearing a mask) during COVID-19 pandemic. However, some patients wear gloves, which is a possible barrier to proper examination. The aim of this study was to determine the difference in oxygen saturation measurement with or without the use of powder-free nitrile gloves.

Methods: A prospective quasi-experimental before and after study was conducted in a primary care practice (PCP) from Madrid. Intervention consisted in measuring oxygen saturation (SpO2) for each participant covering a finger with a powder-free nitrile glove and a posterior measure without glove. Data collection was obtained from June to July 2020 with patients of the PCP. Variables included were demographic data (age and sex), respiratory medical history and suspicion of COVID-19. Descriptive statistics were expressed as frequencies or means with its standard deviation (SD). Effect of gloves was obtained performing Student's t-test and agreement was determined by Bland-Altman analysis. Data was stratified by age range.

Results: 177 patients participated in the intervention, mean age was 58.7 (SD: 18.8) years and 53.7% were female, 19.8% had smoke habit, 18.1% had respiratory medical history and 27.7% were suspicious COVID-19 case. No differences were observed in SpO2 intervention across age groups (*p* value 0.058 with gloves and 0.150 without). There were statistical significance difference in: patients <50 years (SpO2: +0.65), 50-75 years (SpO2: +0.62), females (SpO2: +0.79), smokers (SpO2: +0.60) and COVID suspicious cases (SpO2: +0.64). Bland-Altman analysis was performed, mean difference was -0.56 ± 1.38% (95% CI, -0.77 to -0.35), and the limits of agreement were -3.32 and 2.19%.

Conclusions: The use of powder-free nitrile glove do not change SpO2 with pulse oximetry in general population. However, those patients with potential lung affection might have measures without gloves. Nursing is crucial to educate and prevent from COVID-19 infection.

Background

The World Health Organization (WHO) declared New Coronavirus 2019/2020 (COVID-19) a pandemic on March 11, 2020 (1). As of January 23, 2021, 95,612,831 cases of COVID-19 have been registered worldwide, with 2,499,560 confirmed by reverse transcription polymerase chain reaction (RT-PCR) in Spain (2). A total of 578,371 positive cases have been registered in Madrid (3).

The SARS-CoV-2 transmission mechanism is still being described, and current studies suggest that close contact of infected respiratory secretions to oral, nasal or conjunctival mucosa, either directly or indirectly, could transmit it (4). Additionally, airborne transmission has been recognized (5). The WHO has implemented physical distancing, facial masks and hand hygiene as tools to avoid SARS-CoV-2 infection. These recommendations have been followed widely by the global population. In addition, other protective behaviours, such as wearing face shields or gloves in public, have been frequently implemented, although

neither the WHO nor the Center for Disease Control and Prevention (CDC) recommend these measures (6–7).

The classical triad of COVID-19 symptoms includes fever, dyspnoea and cough, and pneumonia has been described as one of the primary complications. Physical examination can help to determine COVID-19 progression, which can be mild or severe, depending on respiratory effects and oxygen saturation (SpO2). Peripheral capillary SpO2 can be measured by pulse oximetry. The device works through a red-light beam that is sent to the finger and measures the light wavelengths absorbed by oxygenated haemoglobin. Normal SpO2 values range between 95% and 100% with a deviation of 2%. Values below 95% at rest can be associated with several acute and chronic diseases (8). The severity of SARS-CoV-2 infection can be monitored by pulse oximetry, and values lower than 94% are correlated with more serious infection (9).

During the COVID-19 pandemic, the organization of primary care practices has changed drastically. Patients whose doubts could be resolved by remote assessment did not come to the practice. Those with mild and uncomplicated symptoms of COVID-19 came to the practice for RT-PCR and examination if needed. Many patients who came to primary care practices wore their own gloves as they feared becoming infected. At the beginning of these visits, each patient was evaluated by nurses to assess whether COVID-19 symptoms were present. Temperature was collected in all cases as well as SpO2 if they had respiratory symptoms. In some cases, gloves were not removed and SpO2 measure did not seem to differ from those occasions where patients did not have gloves. However, there was no evidence to support this practice. Therefore, the aim of this study was to evaluate differences in SpO2 measurements with or without gloves using pulse oximetry in the general population across different ages and in patients with respiratory diseases.

Methods

Study design and sample

This was a prospective quasi-experimental before and after study. Data were collected, and intervention was performed from June 9, 2020 to July 7, 2020 in a primary care practice (PCP) in Madrid, Spain (Federica Montseny PCP). Thirteen nurses and fourteen general physicians (GPs) worked in this centre, and they provided medical care to 21,814 patients.

Participants: Patients who were assessed at triage or at nursing consultation for any reason were invited to participate. The inclusion criteria were as follows: patients over 18 years old who sought medical advice *(if patients were between 14 and 17 years, their legal guardian could provide permission for them to participate)* and patients who gave their informed consent after oral information about the study. Exclusion criteria included patients with hand deformities, terminally ill patients, patients who had tremors or severe anaemia because it could interfere with the measurements and patients with nail polish or dirty nails.

Sample size

To calculate the sample size for the comparison of two paired means of data, a type I error of 0.5, a test power of 0.8, and a clinical effect magnitude (difference in SpO2 before and after taking the gloved value) of 2 were established with a correlation of 0.5 and a standard deviation of 6. Using Stata version 16, a minimum sample size of 73 individuals was obtained.

Intervention: Study consisted in measuring SpO2 for each participant covering a finger with a powder-free nitrile glove and a posterior measure without glove.

First, informed consent was requested, and if the patients agreed, they were asked to participate in the study.
The following data were collected during the visit: age, sex (male or female), smoking habit (yes or no), respiratory chronic disease (asthma or COPD) and suspicion of COVID-19 (yes or no). Next, hydroalcoholic gel was offered for hand hygiene, pulse oximetry was always assessed in the fourth finger of the right or left hand, and data were collected. Second, patients were provided with fingerstall powder-free nitrile examination gloves of the appropriate size, and SpO2 measurement was repeated and recorded (Fig. 1). In those cases where patients had oxygen saturation below 95%, we established a protocol (Supplementary file 1).

The pulse oximeter used was GIMA, model OXY-6. The gloves were powder-free nitrile examination gloves of the Sensiflex Lite brand in three sizes, S, M and L.

Variables and data collection

The information recorded included demographic data (age and sex), respiratory medical history (smoking habit and respiratory diseases) and suspicion of COVID-19. Variables were classified as follows.

- Qualitative variables: sex (male or female), smoking habit (dichotomous), respiratory chronic disease (asthma or Chronic Obstructive Pulmonary Disease (COPD)) and suspicion of COVID-19 (dichotomous).
- Quantitative variables: age, SpO2 measures before and after the intervention (represented as percentage and taken on air).

Data analysis: Descriptive statistics were performed. Qualitative variables are expressed as frequencies (standard deviation (SD)), and quantitative variables are expressed as the mean (SD). The effect of the use of gloves or not was determined by comparing both measurements. For this purpose, Student's t-test was performed for the data: quantitative variables of dependent samples with values before and after an intervention (use of nitrile gloves). Bland-Altman analysis was used to determine the agreement between SpO2 with gloves and without gloves. The data were analysed separately in three age ranges: <50 years, 50–75 years and ≥ 75 years.

Results

Descriptive data are represented in Table 1. A total of 177 patients were enrolled, the mean age was 58.7 (SD: 18.8) years, and 53.7% were female. Smoking habit was present in 19.8% of the sample, more frequent in those < 50 years (33.0%, p < 0.001). The 18.1% had respiratory medical history, asthma was 11.3% and chronic obstructive pulmonary disease was present in 6.8% but no statistical difference was found across age groups. Suspicious COVID-19 infection was detected in 27.7% of the sample, being more frequent in those < 50 years (40.0%, p < 0.028).

Table 1
Patients demographics and comorbidities characteristics stratified by age groups.

	All	**< 50 years**	**50–75 years**	**≥ 75 years**	***p* value**
Total number, n (%)	177 (100)	57 (32.2)	76 (42.9)	44 (24.9)	
Age, mean (SD)	58.7 (18.8)	36.5 (9.3)	62.0 (7.1)	81.9 (4.9)	< 0.001
Sex, n (%)					
Female	95 (53.7)	30 (53.0)	43 (57.0)	22 (50.0)	0.77
Male	82 (46.3)	27 (47.0)	33 (43.0)	22 (50.0)	
Respiratory medical history					
Smoke habit, n (%)	35 (19.8)	19 (33.0)	14 (18.0)	2 (5.0)	0.001
Asthma, n (%)	20 (11.3)	9 (16.0)	6 (8.0)	5 (11.0)	0.097
COPD, n (%)	12 (6.8)	0 (0.0)	7 (9.0)	5 (11.0)	0.097
Suspicious COVID-19 case, n (%)	49 (27.7)	23 (40.0)	18 (24.0)	8 (18.0)	0.028
Legend: SD (standard deviation); COPD (chronic obstructive pulmonary disease)					

Differences in SpO2 measures using gloves are shown in Table 2. Using powder-free nitrile gloves overestimate SpO2 in all variables analysed but it was an increase of less than 1%. We observed significant differences in SpO2 values in patients < 50 and 50–75 years, from 97.61% with gloves and 96.85% compared to 96.96% and 96.23% respectively (*p* value 0.001 and 0.002). In addition, our findings revealed differences in females with gloves (SpO2 97.32%) and without gloves (SpO2 96.53%, *p* value 0.001) and in smoking habits (SpO2 of 96.97% with gloves and SpO2 96.37% without, *p* value 0.003). And no statistical differences were detected in patients who had respiratory diseases. When a Bland-Altman analysis was performed to assess the agreement between the results of SpO2 without gloves and SpO2 with gloves, the mean difference was − 0.56 ± 1.38% (95% CI, -0.77 to -0.35), and the limits of agreement were − 3.32 and 2.19% (Fig. 2).

Table 2
Differences between SpO2 measured with and without gloves.

	SpO2 with gloves (%)	SpO2 without gloves (%)	Difference (%) (SpO with - SpO2 without gloves)	Student`s T test (*p* value)
Age group				
Patients < 50	97.61	96.96	0.65	0.001
Patients 50–74	96.85	96.23	0.62	0.002
Patients ≥75	96.43	96.06	0.37	0.197
Sex				
Female	97.32	96.53	0.79	0.001
Male	96.60	96.30	0.30	0.091
Respiratory medical history	97.00	96.36	0.64	0.001
Smokers	96.97	96.37	0.60	0.003
COPD	95.00	94.83	0.17	0.811
Asthma	96.80	96.35	0.45	0.329
Suspicious of COVID-19 case	97.00	96.36	0.64	0.001
Legend: SpO2 (oxygen saturation); COPD (chronic obstructive pulmonary disease)				

Discussion

Up to 177 patients participated in the intervention with a mean age of 58.7 (SD: 18.8) years and 53.7% were female. There were differences between the use and absence of powder-free nitrile examination gloves when measuring SpO2. The use of gloves overestimates by less than 1% the measure of SpO2 in patients and was statistical significant in female patients, < 75 years, smokers and those with suspicion of COVID-19.

Oximetry is a common technique in different nursing settings and there are some studies that describe the influence of oximetry when any surface (nail polish, gloves, dirt, etc.) is on the nail or the finger. We should keep in mind that SpO2 varies from different oximetry brands (10–11). Bickler *et al.* studied the differences between SpO2 and haemoglobin oxygen saturation. SpO2 was measured by oximetry, and haemoglobin oxygen was measured by a haemoximeter blood gas analyser. They described the mean bias (the difference between SpO2 and haemoglobin oxygen saturation) among different oximetry brands according to the pigments on the skin (dark, intermediate and light) (10). They found that SpO2

was overestimated between 2–3% in dark subjects when the SpO2 was 60–70%; however, these differences disappeared when SpO2 was between 90–100%. Adler *et al.* found no differences among pigments on the skin when they compared oximetry and arterial blood sampling in the Accident & Emergency (A&E) department (12). But Sjoding *et al.* described recently that Black patients had almost three times the frequency of occult hypoxemia than White patients when using pulse oximetry compared with arterial blood gas test (13). Then, racial bias according to differences in skin pigment should be considered when measuring SpO2 with pulse oximetry.

Focusing on the surface of the skin, some studies have been performed primarily in women by studying henna tattoos influence in SpO2. Mitra Zolfaghari *et al.* found no significant differences between measurements in 100 young women (SpO2 in henna finger: 95.32% vs SpO2 in control finger: 95.29%, *p* value 0.87) (14). Sütçü Çiçek *et at.* compared the SpO2 of normal fingers to henna tattoos and 13 different colours of nail polish in 33 healthy women (15). They found similar results in henna tattoos, but nails that were polished had higher SpO2 (polished nail: 98.00% vs control finger; 97.87%). Our findings support their results because glove caused an increase of SpO2. However, an overestimation of less than 1% is not considered clinically relevant. On the other hand, considering nail surface, the effect of nail polish in the SpO2 measure is controversial. In 1986, Kataria published that nail polish did not interfere with oximetry, but she did not examine the colour of the nail polish (16). While other studies conclude that blue, green, black, brown and red colours interfere in SpO2 obtained with pulse oximetry with a difference of less than 1–2% (17–19). A further aspect that must be addressed is the corporal temperature. Ralston *et al.* concluded that there are differences in pulse oximetry and in vitro oximetry saturation if the corporal temperature varies; they had as reference a central temperature of 37°C and found that while SpO2 could vary in hyperthermia or hypothermia, these differences were not clinically relevant (20). This situation is not a key aspect in COVID-19 disease, as fever is defined as a peripheral temperature over 37.3°C (4) so SpO2 measure could be modified by hyperthermia of 37.5ºC. Additionally, it should be taken into account that age can modify SpO2, and patients ≥ 75 years had the lowest SpO2 (96.06%). This finding is similar to a population of nursing home patients who had a basal value of 96.40% (22). Lung loss of elasticity could be the cause of older people having a lower SpO2 value. Finally, our study is similar to Burge *et al.* Both studies were conducted because of the challenges that nurses faced in clinical scenarios. They found that there were no differences in the measures of SpO2 with or without gloves; however, their study did not detail the type of gloves or the oximetry brand used. Our findings are consistent with their results, furthermore our sample is larger (n: 177) than theirs (n: 50) (21).

According to our study, the use of gloves overestimates oximetry by nearly 1% and this difference is not clinically relevant. Then it could be accepted to determine SpO2 in those population who are using gloves. However, neither the WHO nor the CDC recommends the use of gloves to prevent COVID-19. The data obtained in this study are useful in primary care, such as in the A&E department, so no generalisation of using glove should be stablished in general population. Then, nurses are crucial for promoting health and preventing disease through health education. This task has been recognized by the WHO and is essential during the COVID-19 pandemic (23). Nurses have expanded their competencies during COVID-19 by caring for patients with mild symptoms, collecting RT-PCR, and recommending

isolation and hygienic measures. They have increased their roles as they are in charge of triage not only in the A&E department but also in primary care practices.

Strengths And Limitations

Our study has the strength of collecting a large sample of patients; furthermore, we studied respiratory patients, suspicious COVID-19 patients and smokers. We only used one type of glove and a single pulse oximeter model, so our results can be reproduced under the same conditions in different settings.

Some limitations should be considered. First, participants were only recruited from a single practice. Second, we did not collect the colour of the skin of our patients or their temperature, which could modify SpO2 values. Additional studies are needed to explain how different gloves (materials, colours, etc.) may interfere in SpO2 measurements.

Conclusions

Using powder-free nitrile gloves overestimate SpO2 measure less than 1%. Differences observed where not clinically relevant. We recommend not to use gloves in those patients with lung affection or COVID-19 suspicious cases. Nurses have an essential role in health education and prevention in COVID-19 pandemic.

List Of Abbreviations

New Coronavirus 2019/2020: COVID-19

World Health Organization: WHO

Transcription polymerase chain reaction: RT-PCR

Primary care practice: PCP

Oxygen saturation: SatO2

Centers for Disease Control and Prevention: CDC

General Physicians: GPs

Chronic Obstructive Pulmonary Disease: COPD

Standard deviation: SD

Declarations

Ethical approval and consent to participate: The protocol of the study was approved by the Committee on the Ethics of Clinical Research of the *Hospital 12 de Octubre* on June 9, 2020 (Protocol No: P20/282). The study was performed in accordance with the ethical standards of the Declaration of Helsinki (1964) and its subsequent amendments. Data were processed in accordance with Organic Law 3/2018 of December 5, Protection of Personal Data and Guarantee of Digital Rights. All participants provided informed consent. Guideline considered corresponded to nursing specific assessment (8).

Consent for publication: Not applicable

Availability of data and materials: The datasets generated and/or analysed during the current study are not publicly available due to the need to maintain the anonymity of participants but are available from the corresponding author on reasonable request and with permission of the Madrid healthcare system.

Conflict of interests: The authors declare they have no competing interests.

Funding: This manuscript has received a grant from the Foundation for Biomedical Research and Innovation in Primary Care (FIIBAP) for translation and publication in 2020 (FIIBAP/oct20).

Authors' contributions: Study concept and design: MMG, RNP, MGC, and SAB. Analysis and interpretation of data: SAB, MGC, MMG, and RNP. Drafting of the manuscript: MMG, RNP, SAB, and MGC. RNP and MGC prepared tables and figures. All authors have read and approved the finalized manuscript.

Acknowledgements: We would like to thank all the healthcare professionals who work at the Federica Montseny PCP. The nurses who collaborated in recruiting patients were María Tamara Zarco Duque; Ana Yarritu Sánchez; Fabia Sara Sananes Venero; María Isabel Vaquero Fuente; Raquel Blanco Corral; María de las Mercedes Zumel Álvarez; Álvaro Orihuel Pérez-Klett; and María Pilar Jareño Montserrat. This work could not have been done without their effort and dedication. We would like to thank Cristina Lozano Hernández and Miguel Menéndez for guidance in the revision of the manuscript.

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Figures

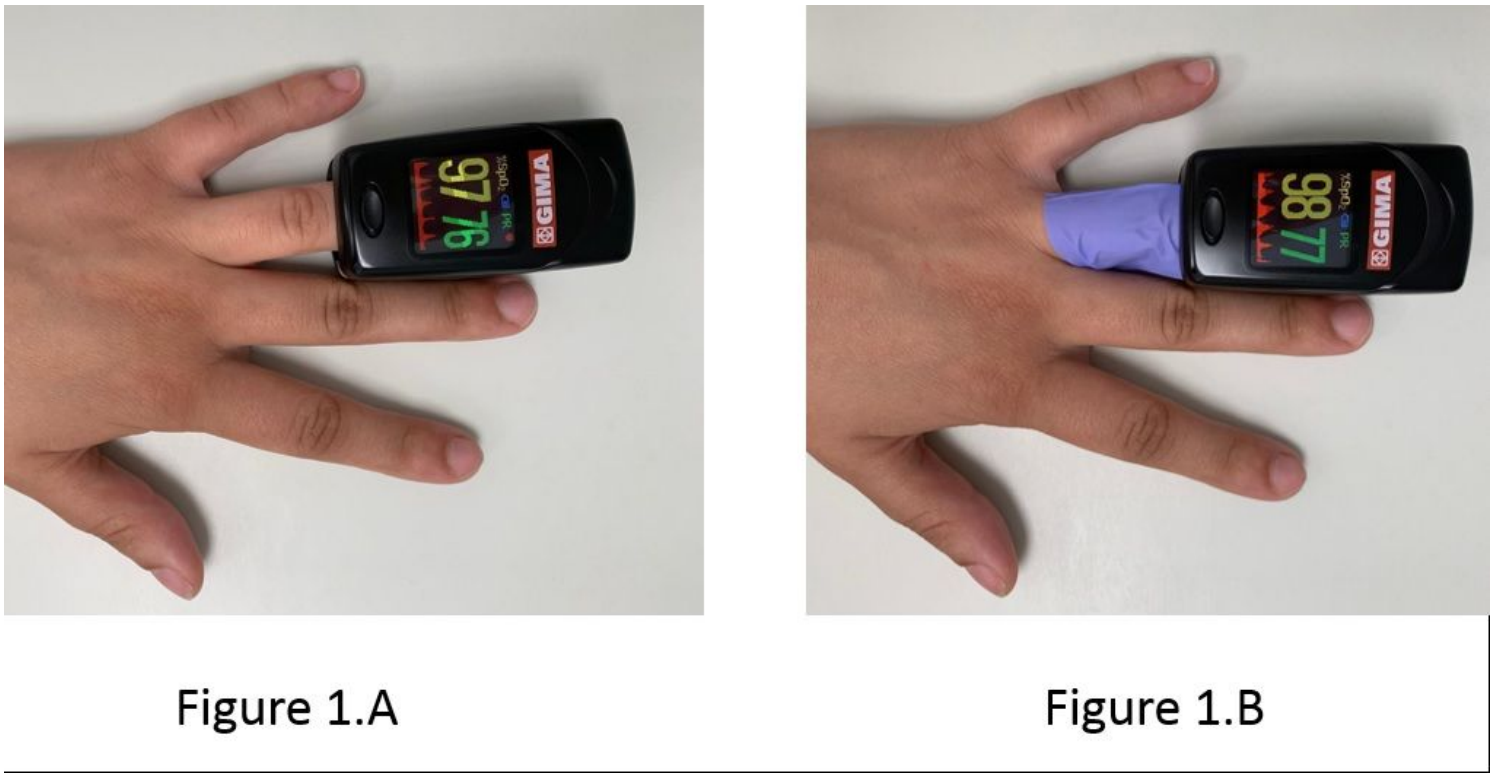

Figure 1

Peripheral capillary oxygen saturation measured with pulse oximetry. A. Measured without gloves. B. Measured with gloves.

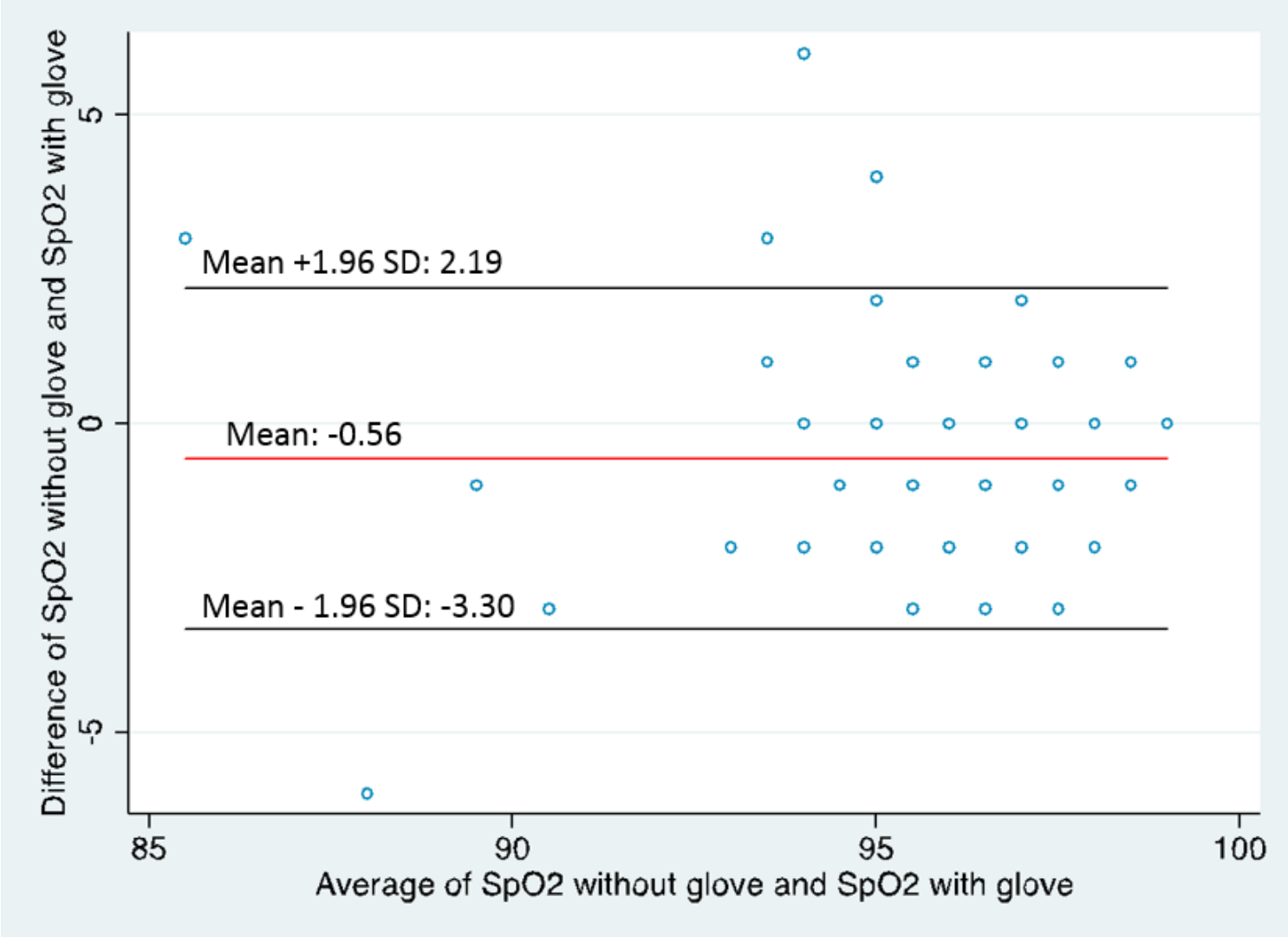

Figure 2

Bland and Altman plot of the difference between SpO2 with and without gloves against the mean of the SpO2 with and without glove of the study population. SpO2 (oxygen saturation), SD (standard deviation)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementaryfile1.jpg