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ANALYSIS OF THE EFFECT OF NAIL POLISH COLOUR ON OXYGEN SATURATION (%SPO2) LEVELS WHEN MEASURED WITH A FINGERTIP PULSE OXIMETER

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Abstract: Fingertip pulse oximeters were widely used during the COVID-19 pandemic as the main and readily available device (%SpO2). The aim of this study was to determine the extent to which different colours of gel nail polish affect oxygen saturation (%SpO2) measurements. Saturation measurements were taken using the Finger Clip Pulse Oximeter P-01 (China) device, routinely available during the COVID-19 pandemic. The study included 54 healthy female volunteers of undergraduate cosmetology students aged between 24 and 36 years. Each participant was given an individual fingertip pulse oximeter to measure saturation on different fingers painted with different colours of gel nail polish: red, orange, yellow, green – fingers II-V of the right hand; blue, navy, violet, no colour – fingers II-V of the left hand. Increasing wavelength (from violet ~400 nm to red ~680 nm) increased mean saturation levels. Long-wavelength colours ("red") distorted the measurement results to a lesser degree than short-wavelength colours ("green"). Nail polishes significantly influence the results of oxygen saturation measurements, especially of dark and metallic colour. Interference resulting from long-wavelength colours (e.g. red) is minimal, while short-wavelength colours (e.g. green) cause the most interference. In particular, light-absorbing colours (e.g. green) significantly reduced the $\%SpO_2$ ($P = 0.032$), in contrast to longer-wavelength colours (e.g. red).
Keywords: health safety, nail polish, oxygen saturation

1. INTRODUCTION

Modern technologies are used in many areas of life, and have gained a particularly strong position in healthcare, participating in almost all branches of medicine - from maintaining a healthy lifestyle to remotely monitoring the body's physiological functions (Page, 2021; Aggarwal et. Al., 2023; Hess, 2024; Bishnoi et al., 2025). This is especially important

during the COVID-19 pandemic (Bedford et al., 2020; García et al., 2020; McKee & Stuckler, 2020). Researchers suggest that one of the symptoms of coronavirus infection may be a decrease in blood oxygen saturation due to infection of the carotid bodies by SARS-COV-2 (Couzin-Frankel, 2020; Luks & Swenson, 2020; Tobin et al., 2020; Wilkerson et al., 2020; Greenhalgh et al. 2021; Montemerani et al., 2021; Rahman et al., 2021; Wilson-Baig, 2021; Fallahi et al., 2024). Fingertip pulse oximeters were widely used during the COVID-19 pandemic as the main and readily available device (%SpO2) (Badgujar , 2020; Satici et al., 2020; Mukhtar et al., 2021; Pérez et al., 2021; Lee et al., 2022; Roberts, 2022; Wojtasz et al., 2022; Hol et al., 2023; Maradey–Lázaro, 2023; Alassafi et al., 2024; Muhammad et al., 2024). Back in the 1980s, it was stated that nail polish should be routinely removed before using pulse oximetry because it interferes with the measurement to a varying degree (Coté et al., 1988; Hinkelbein et al., 2007; Haq et al., 2018; Raipure et al., 2019; Doğan et al., 2021; Ballesteros-Peña et al., 2015; Yikar et al., 2019; Hossain et al., 2021). Recently, gel manicure have gained high popularity due to their attractiveness and durability. It has been found that gel manicure can lead to an overestimation of actual readings, delaying the detection of hypoxaemia (Yeganehkhah et al., 2019; Yek et al., 2019).

The aim of this study was to determine the extent to which different colours of gel nail polish affect oxygen saturation (%SpO2) measurements.

2. METHODOLOGY

A statistical analysis was performed, taking into consideration light wavelength of different colours of gel nail polish and blood oxygen saturation level. The following colours of gel nail polish were analysed: blue, violet, orange, green, navy, yellow, red; and in quality control measurements without nail polish.

Saturation measurements were taken using the Finger Clip Pulse Oximeter P-01 (China) device, routinely available during the COVID-19 pandemic. The study included 54 healthy female volunteers of undergraduate cosmetology students aged between 24 and 36 years. The results of 6 female volunteers were excluded for certain varnish colours because the light wavelength of the colour of their nail polish significantly deviated from the colour standard. The participants were all certified gel manicure professionals (completed 25-hour training – 1 ETPS credit). Each participant was given an individual fingertip pulse oximeter to measure saturation on different fingers painted with different colours of gel nail polish: red, orange, yellow, green – fingers II-V of the right hand; blue, navy, violet, no colour – fingers II-V of the left hand. The data were divided into two groups: "with nail polish" and "without nail polish". For each group and colour the mean saturation value and standard deviation (SD) were calculated. The Student's t-test for independent samples with unequal variances (Welch's) was used to compare the groups. The test was two-sided because the study was of exploratory nature and did not assume any a priori trend of the results. P-values were presented accurately – in accordance with the guidelines. No statistical power analysis was performed as it was a preliminary study. Analyses were performed using Microsoft Excel 2019, R v4.2.2 and Python. The aim of the study was to test whether the colour of nail polish (more specifically, its wavelength) influences the blood oxygen saturation index (%SpO2) measured with a fingertip pulse oximeter. Differences between adjacent colours of the spectrum, for example: green and orange. Colours were compared with wavelengths to rank them according to their physical properties, mean saturation value for each colour was calculated, and a t-test

(independent samples) was used to see if there were statistically significant differences between colour pairs. Therefore, a t-test was used to compare the mean values of two independent groups (in our case, saturation values for two different nail polish colours). The test enables to find out whether differences between two colours should be considered random or real (significant). A t-test with unequal variances was chosen because the group sizes could have been different and the variances were not necessarily the same.

3. RESULTS AND DISCUSSION

Based on the statistical analysis, it can be concluded that the colour of nail polish can, in some cases, influence the results of saturation measurements using the fingertip pulse oximeter (Fig. 1).

In particular:

The green nail polish (530 nm) caused statistically significantly lower saturation values compared to the orange polish (620 nm), suggesting that it may interfere with the measurement to a greater extent.

The differences between red (700 nm) and green nail polishes, orange and yellow nail polishes (580 nm) as well as red and yellow nail polishes were not statistically significant, meaning that in these cases the colour had no clear effect on the saturation result.

A possible explanation for these results might be that colours with wavelengths close to the range of light emitted or received by the pulse oximeter (especially green) may absorb or reflect light in a way that interferes with the measurement. Orange nail polish, being closer to red in the spectrum, appears to affect the results to a lesser degree.

These results suggest the need for caution when interpreting saturation measurements in people with painted nails, especially to green colour.

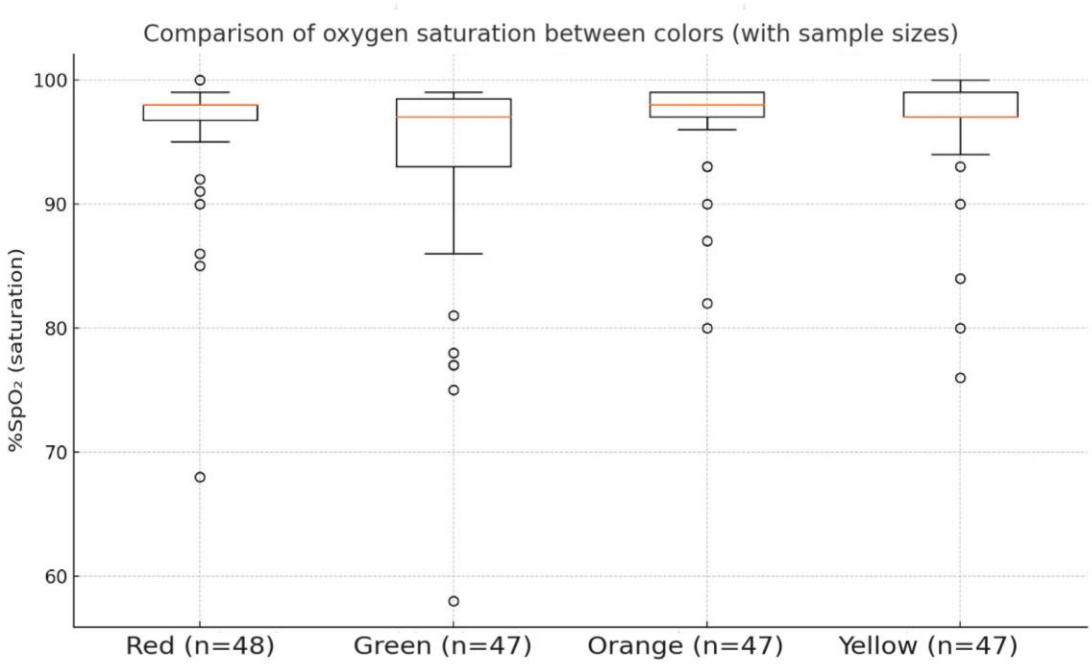

Fig. 1. Comparison of oxygen saturation (%SpO2) between nails painted to different colours of nail polish.

Only the difference between green and orange nail polish turned out to be statistically significant (p = 0.0322), i.e. non-random.

Comparison of the "with nail polish" and "without nail polish" groups.

The analysis examined whether the mere presence of nail polish – irrespective of its colour – affected the results of oxygen saturation (%SpO_2) measurements carried out with a pulse oximeter. The mean saturation in the "with nail polish" group was 95.50%, while in the "without nail polish" group it was 96.88% (Fig. 2).

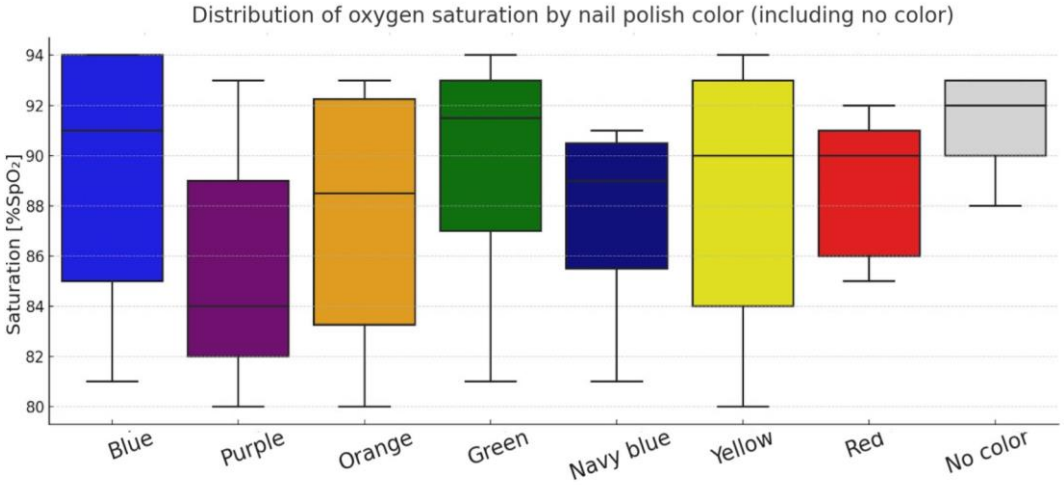

Fig. 2. Oxygen saturation levels depending on the colour of nail polish.

- This difference was confirmed by the Student's t-test (the Welch test), which showed statistical significance:
  T = -2.99, p = 0.032 (p < 0.05) – Welch's t-test, two-sided.
- This means that, regardless of its colour, nail polish statistically significantly reduced the results of saturation measurements. It can be speculated that a layer of nail polish – regardless of its colour – acts as an optical filter, limiting or altering the way light from the pulse oximeter passes through the nail plate. It may be caused by light absorption by pigments or its scattering by glitter or metallic additives.
- These results confirm previous observations that not only a specific colour (e.g. green), but in general the presence of nail polish can affect saturation measurements. Therefore, measurements conducted on individuals with painted nails may be less accurate and saturation levels may be underestimated. This should be taken into account especially in clinical and diagnostic settings (Fig. 3).

Mean saturation levels depending on the colour of nail polish:

- Green nail polish: mean %SpO_2 = 86% ± 3.4%
- Red nail polish: mean %SpO_2 = 98% ± 1.5%
- Comparison between green and orange nail polish: T = -2.32, P = 0.032 – statistically significant difference.
  Other colour comparisons showed no statistically significant differences (P > 0.05 in each case).

Wavelength vs saturation:

- Increasing wavelength (from violet ~400 nm to red ~680 nm) increased mean saturation levels.
- Long-wavelength colours (“red”) distorted the measurement results to a lesser degree than short-wavelength colours (“green”).

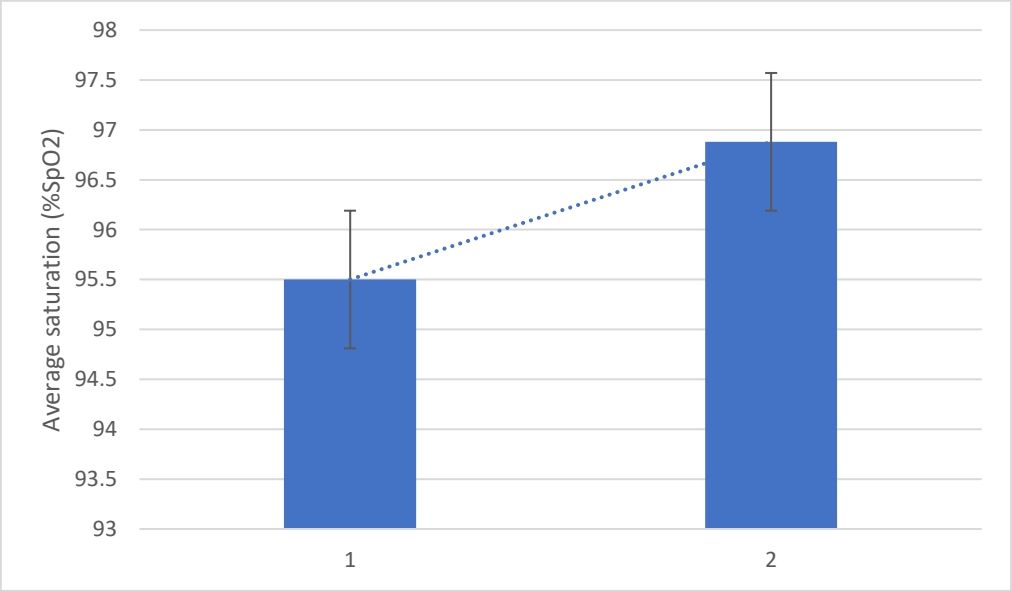

Fig. 3. Average oxygen saturation for nails with and without nail polish.

4. CONCLUSIONS

1. Nail polishes significantly influence the results of oxygen saturation measurements, especially of dark and metallic colour.
2. Interference resulting from long-wavelength colours (e.g. red) is minimal, while short-wavelength colours (e.g. green) cause the most interference.
3. In particular, light-absorbing colours (e.g. green) significantly reduced the $\%SpO_2$ ($P = 0.032$), in contrast to longer-wavelength colours (e.g. red).

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