

## INVESTIGATING THE IMPACT OF HENNA APPLICATION ON PULSE OXIMETRY READINGS

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### Abstract

**Background:** Pulse oximetry is a widely used, non-invasive method for measuring oxygen saturation (SpO<sub>2</sub>). However, external factors such as nail polish and skin dyes may interfere with its accuracy. Henna, a commonly applied natural dye, has been hypothesized to affect pulse oximetry readings, leading to potential diagnostic inaccuracies. This study aims to evaluate the impact of henna application on SpO<sub>2</sub> measurements. **Materials and Methods:** A total of 100 healthy female participants aged 18–22 years were recruited. Pulse oximetry readings were recorded pre-application and at multiple post-application time points (Day 1, Day 2, and Day 7). The test group had henna applied to one finger, while the control group had no application. SpO<sub>2</sub> values were compared across time points to determine the extent of interference. Statistical significance was assessed using paired t-tests, with a significance threshold of  $p < 0.05$ . **Result:** Baseline SpO<sub>2</sub> values were  $97.95\% \pm 0.5$  in both groups. A significant reduction in SpO<sub>2</sub> was observed in the henna-applied finger on Day 1 ( $96.44\% \pm 0.6$ ,  $p < 0.001$ ), with partial recovery on Day 2 ( $96.93\% \pm 0.5$ ,  $p < 0.001$ ) and near-baseline levels by Day 7 ( $97.42\% \pm 0.4$ ,  $p < 0.001$ ). The control group showed no significant variations. **Conclusion:** Henna application causes a temporary but statistically significant reduction in SpO<sub>2</sub> readings, which recovers within a week. Clinicians should consider this interference when interpreting pulse oximetry results in individuals with henna-stained fingers. Further research is recommended to explore underlying mechanisms and alternative measurement sites.

## INTRODUCTION

Pulse oximetry is a widely utilized non-invasive method for monitoring arterial oxygen saturation (SpO<sub>2</sub>) and is considered an essential tool in critical care, anesthesia, emergency medicine, and perioperative monitoring.<sup>[1]</sup> It provides real-time oxygenation status, assisting in early detection of hypoxemia and respiratory distress. However, various external factors, including skin pigmentation, nail polish, and dyes such as henna, can influence the accuracy of pulse oximetry readings.<sup>[2,3]</sup>

Henna, a plant-derived natural dye commonly applied to the skin for cultural, cosmetic, and medicinal purposes, contains lawsone (2-hydroxy-1,4-naphthoquinone), which binds to keratin in the epidermis, imparting a deep reddish-brown coloration.<sup>[4,5]</sup> The optical properties of henna may interfere with pulse oximetry by altering the light absorption and transmission of the sensor, potentially leading to erroneous SpO<sub>2</sub> measurements.<sup>[6,7]</sup> Despite

the widespread use of henna, limited studies have investigated its precise effect on pulse oximetry accuracy.

Accurate measurement of oxygen saturation is crucial for clinical decision-making. If henna significantly affects SpO<sub>2</sub> readings, it may lead to misinterpretation of oxygenation levels, unnecessary interventions, or failure to detect hypoxia. Identifying the duration and extent of henna-induced interference will provide valuable insights for healthcare professionals managing patients with henna application.

Hence, the present work was undertaken to evaluate the impact of henna application on pulse oximetry readings and determine its potential interference with oxygen saturation (SpO<sub>2</sub>) measurements. This study specifically aims to assess pulse oximetry readings before and after henna application and compare pre- and post-application values to identify any significant variations. Understanding the extent of this interference is crucial for ensuring the accuracy of

pulse oximetry measurements in individuals with henna-stained fingers, particularly in clinical and emergency settings.

## MATERIALS AND METHODS

### Study Design and Setting

This prospective observational study was conducted at Government Medical College (GMC), Siddipet, Telangana, in December 2024. The study aimed to assess the impact of henna application on pulse oximetry readings by comparing SpO<sub>2</sub> measurements taken before and after henna application over a one-week period.

#### Study Population and Sample Size

A total of 100 healthy female participants, aged 18–22 years, were enrolled in the study based on predefined inclusion and exclusion criteria.

#### Inclusion Criteria

Healthy female subjects aged 18–22 years

Normal oxygen saturation at room temperature

Willing to participate and provide informed consent

#### Exclusion Criteria

Subjects unwilling to participate

Individuals with any known physical or mental health conditions

Presence of cardiovascular disorders such as congenital heart disease or heart failure

Any respiratory disorders that could affect SpO<sub>2</sub> measurements

#### Study Procedure

#### Effect of Henna Application on Pulse Oximetry Readings

Participants were instructed to apply henna to the distal phalanx of the left index finger (test group), while the right index finger remained untreated (control group). The henna was left for 2 hours, after which it was scraped off.

Pulse oximetry readings were recorded at four time points using a standardized pulse oximeter: Baseline (Pre-henna application), Day 1 (2 hours post-henna application), Day 2, Day 7

The difference in SpO<sub>2</sub> readings between the henna-applied (test) and control fingers was recorded and statistically analyzed to determine the extent of interference.

#### Study Tools and Instruments

**Pulse Oximeter:** A standardized non-invasive SpO<sub>2</sub> sensor was used to measure oxygen saturation and radial pulse.

**Henna Application:** Natural henna paste was used to ensure uniform application among participants.

#### Outcome Measures

**Primary Outcome:** Changes in SpO<sub>2</sub> readings following henna application at different time points.

#### Statistical Analysis

Data were analyzed using SPSS (Statistical Package for Social Sciences) version 30.0. Paired t-tests were used to compare SpO<sub>2</sub> readings before and after henna application. A p-value < 0.05 was considered statistically significant.

#### Ethical Approval

Ethical clearance was obtained from the Institutional Ethics Committee (IEC) of Government Medical College, Siddipet before participant recruitment. Written informed consent was obtained from all participants prior to enrollment. This study was conducted in accordance with the ethical guidelines of the Declaration of Helsinki.

## RESULTS

### Effect of Henna Application on Pulse Oximetry Readings

To assess the impact of henna application on pulse oximetry readings, SpO<sub>2</sub> values were recorded before and after henna application. The pre-application SpO<sub>2</sub> reading was 97.95% ± 0.5. After henna application, a significant decrease in SpO<sub>2</sub> was observed, reaching 96.44% ± 0.6 on Day 1 (p < 0.001), followed by a gradual recovery over time (Table 1). By Day 7, SpO<sub>2</sub> values had improved to 97.42% ± 0.4, although still slightly lower than baseline levels (p < 0.001).

These findings suggest that henna application interferes with pulse oximetry measurements, leading to a temporary reduction in recorded SpO<sub>2</sub> values. However, the readings tend to normalize over time, with near-complete recovery by Day 7.

### Comparison of Pulse Oximetry Readings Pre and Post Henna Application

A comparative analysis of pre- and post-application SpO<sub>2</sub> values demonstrated a statistically significant reduction in oxygen saturation following henna application (Table 2). On Day 1, SpO<sub>2</sub> dropped by 1.51%, with a gradual improvement observed on Day 2 (-1.02%) and Day 7 (-0.53%). The significant reduction on Day 1 and Day 2 (p < 0.001) confirms that henna application temporarily affects pulse oximetry readings.

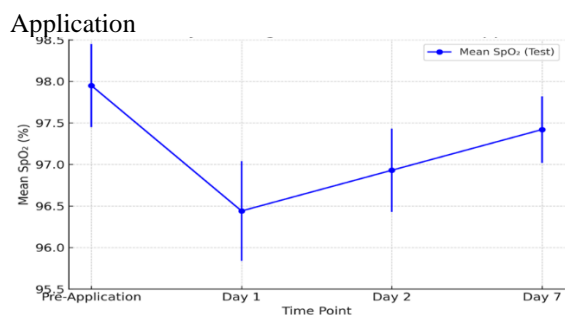
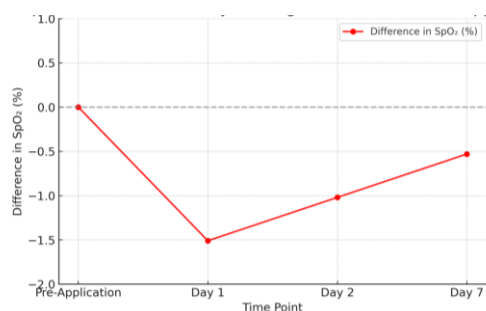
Overall, these results indicate that henna application on fingers leads to a temporary yet statistically significant decrease in pulse oximetry readings without any physiological alteration in oxygenation levels. The readings progressively recover within a week, suggesting that the interference is short-lived.

**Table 1: Pulse Oximetry Readings Pre and Post Henna Application**

Time Point	Mean SpO <sub>2</sub> (Test) (%)	p-value
Pre-Application	97.95 ± 0.5	-
Post-Application (Day 1)	96.44 ± 0.6	< 0.001
Post-Application (Day 2)	96.93 ± 0.5	< 0.001
Post-Application (Day 7)	97.42 ± 0.4	< 0.001

**Table 2: Comparison of Pulse Oximetry Readings Pre and Post Henna Application**

Time Point	Difference in SpO <sub>2</sub> (%)	p-value
Pre-Application	0	-
Post-Application (Day 1)	-1.51	< 0.001
Post-Application (Day 2)	-1.02	< 0.001
Post-Application (Day 7)	-0.53	< 0.001

**Figure No:1. Pulse Oximetry Readings Pre and Post Henna****Figure No:2. Comparison of Pulse Oximetry Readings Pre and Post Henna Application**

## DISCUSSION

This study aimed to evaluate the impact of henna application on pulse oximetry readings by comparing SpO<sub>2</sub> measurements before and after application. The findings reveal significant interference in SpO<sub>2</sub> readings due to henna, which gradually diminished over time.

### Effect of Henna on Pulse Oximetry Readings

Pulse oximeters estimate arterial oxygen saturation (SpO<sub>2</sub>) using red (660 nm) and infrared (940 nm) light absorption. Henna contains lawsone, which alters light absorption properties and affects pulse oximetry accuracy. The results show a statistically significant reduction in SpO<sub>2</sub> values in the henna-applied finger on Day 1 (96.44% ± 0.6 vs. 97.95% ± 0.5 in the control, p < 0.001), with progressive recovery by Day 7 (97.42% ± 0.4, p < 0.001) (Table 1).

These findings align with previous studies showing that skin pigmentation and topical dyes influence pulse oximetry readings (Ochoa-Gutierrez et al.<sup>7</sup>, 2022). Research by Bensghir et al.<sup>8</sup> (2013) and Deniz Doğan et al.<sup>9</sup> (2021) demonstrated that henna interferes with light absorption, leading to false-low SpO<sub>2</sub> values. Similarly, al-Majed et al.<sup>10</sup> (1994) confirmed henna's impact on pulse oximetry accuracy. Al-Halawani et al.<sup>11</sup> (2023) emphasized that skin pigmentation can compound this effect,

while Sutcu Cicek et al.<sup>12</sup> (2011) found that both nail polish and henna significantly altered SpO<sub>2</sub> measurements, recommending alternative SpO<sub>2</sub> monitoring sites such as the forehead or earlobe.

Given these observations, healthcare providers should be cautious when interpreting pulse oximetry results in individuals with henna. If low SpO<sub>2</sub> values are detected, clinicians should confirm results using arterial blood gas analysis or alternative measurement sites to avoid misdiagnosis.

### Clinical Implications

Henna application significantly interferes with pulse oximetry readings, potentially leading to unnecessary oxygen therapy or failure to detect actual hypoxia (Bensghir et al.<sup>8</sup>, 2013; Deniz Doğan et al.<sup>9</sup>, 2021). As a result, clinicians should consider alternative SpO<sub>2</sub> measurement sites such as the earlobe or forehead in individuals with henna-stained fingers (Sutcu Cicek et al.<sup>12</sup>, 2011). Furthermore, factors affecting pulse oximetry accuracy, including external dyes and variations in skin pigmentation, should be accounted for in patient assessments to ensure accurate oxygen saturation readings (Al-Halawani et al.<sup>11</sup>, 2023).

### Limitations and Future Directions

This study has some limitations that should be acknowledged. The study population was homogenous, consisting solely of healthy young females, limiting its applicability to other age groups, males, or individuals with underlying health conditions. Additionally, only one type of henna was tested, and variations in brand, concentration, and duration of application might produce different effects. The study did not examine long-term effects beyond seven days or variations in pulse oximeter brands and sensor technologies. Future research should explore broader population groups, assess different henna formulations, and investigate longer-term effects on SpO<sub>2</sub> readings.

## CONCLUSION

This study confirms that henna application significantly interferes with pulse oximetry readings, causing a temporary reduction in SpO<sub>2</sub> values. The greatest impact was observed on Day 1 post-application, with gradual recovery by Day 7. These findings highlight the importance of recognizing external factors that affect pulse oximetry accuracy to prevent misdiagnosis and unnecessary interventions. Clinicians should consider alternative SpO<sub>2</sub> monitoring sites when henna is present to ensure accurate oxygen saturation measurements and improve patient safety and diagnostic accuracy.

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