# Quantification of stress and depression level posed by COVID-19 in first-line healthcare workers*

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***Abstract*— After pandemic, healthcare workers experienced a series of emotional and psychological disturbances that could impact their mental well-being. In this study, the feasibility of morphological characteristics of photoplethysmographic (PPG) waveform to quantify stress and depression level posed by COVID-19 in first-line healthcare workers is explored. Results show that higher stress and depression level are moderately correlated with large systolic amplitude and parameters that might indicate early wave reflection. These results suggest that an arterial stiffness, quantified with PPG morphological characteristics, could provide valuable information in assessing mental health.**

## I. Introduction

Since World Health Organization declared the coronavirus disease (COVID-19) outbreak as a pandemic, a global health crisis with sanitary services, especially in the intensive care unit (ICU), to be wrapped in a storm of human infection cases has emerged. Front-line nurses, particularly those with no experience of caring for critically ill patients, face huge workloads and fatigue symptoms. Furthermore, the death of patients whom they care for and misunderstanding with their family members, as well as the risk of infection could lead to emotional and psychological disturbances [1]. COVID-19 has a high impact on the mental health of ICU personnel working in high-intensity epidemic zones, with symptoms of anxiety and depression to be reported more frequently among others [2].

The autonomic nervous system (ANS) plays a key role in the development of mental disorders since it controls the major pathways activated by stressors, including the regulation of heart rate (HR) and vasculature [3]. With the advances in remote measurement technologies, commercial wearable devices can be used to track ANS activity through the processing of biomedical signals, such as the photoplethysmographic (PPG) signal [4]. PPG is a vascular optical measurement technique that can provide information about HR by assessing pulse-to-pulse interval variations, and vascular tone by quantifying changes in the PPG waveform morphology [5,6].

The objective of this paper is to study the feasibility of ANS parameters derived from the PPG signal to quantify stress and depression level posed by COVID-19 in first-line healthcare workers.

## II. Materials and Methods

### A. Database

A total of 80 healthcare professionals from Hospital Clínico Lozano Blesa, Zaragoza, (66 female, mean±std 39.29±11.66 years), who have worked in the during COVID-19 pandemic underwent the following protocol consisting of three sessions:

i. Session1: PPG was measured for 5 minutes in a basal condition. Afterwards, stress was induced by a series of cognitive tests. Participants reported their stress levels on a 100-point Visual Analogue Stress Scale (VASS) [7] at both beginning and end of the Session.
ii. Session2: About 15 days after Session 1, a second PPG was recorded during a basal condition. Additionally, participants reported their depression level using the Patient Health Questionnaire (PHQ2) [8] at the beginning of the session.
iii. Session3: About 90 days after Session1 participants underwent a third Session following the same protocol than that used in Session 1.

For Session1 and Session3, data were available in a total of 143 visits, while 74 visits were available in Session2.

The wristband wearable device EMPATICA E4 was used for recording the PPG and a 3-axes accelerometer (ACC) signals at 64 Hz and 32 Hz, respectively. The device, besides the raw PPG signal, also provides an estimation of HR every 1 second.

### B. PPG feature extraction

Segments with movement artifacts are discarded based on the module of ACC and the moving standard deviation of the PPG signal using a variable threshold that is calculated with a median filter [9]. Then, PPG pulse detection is carried out using a low-pass differentiator and a time-varying threshold [10]. A pulse decomposition analysis (PDA) is applied for obtaining the amplitude ($A_1(i)$), position ($T_1(i)$), and width ($W_1(i)$) of the first inner wave of the i:th pulse [6]. Other morphological features associated with systolic arterial pressure such as the slope $S_1(i) = A_1(i)/T_1(i)$ are calculated. The median value among all pulses is obtained for each pulse waveform characteristic. The mean HR estimation of EMPATICA is also subjected to analysis.

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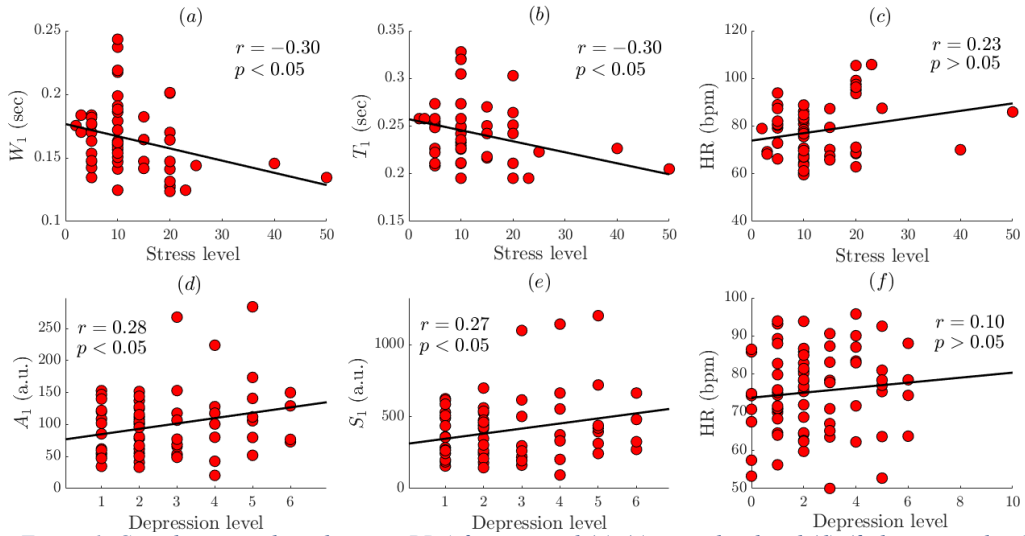


*Figure 1. Correlation analyses between PDA features and (a)-(c) stress level and (d)-(f) depression level.*

### C. Correlation analysis

Pearson's correlation ($r$) analyses are carried out for assessing the linear relation between PPG-derived parameters and stress or depression level. Considering both Session1 and Session3, the stress level is defined as the difference between the second and the first VASS score. Only subjects with positive stress levels are considered. Depression level is defined based on the PHQ2 score reported in Session2. The significance threshold in this study is set to $p < 0.05$.

## III. Results

Results show moderate negative correlations between stress level and both the width ($r = -0.30$) and the position ($r = -0.30$) of the first inner wave (Fig. 1(a), (b)), while a moderate positive association was found for depression level and both the amplitude ($r = 0.29$) and the slope ($r = 0.27$) of the first inner wave (Fig. 1(d), (e)). No significant association was found between HR neither with stress nor with depression level (Fig. 1(c), (f)).

## IV. Discussion

Previous studies have analyzed the relation between ANS parameters derived from PPG and psychological disturbances including stress and depression [6,11]. Higher arterial stiffness is associated with depressive and anxiety disorders [12]. This agrees with the larger peak in systolic part and early wave reflection found in the present study. Although previous research pointed out the utility of pulse-to-pulse interval variations for assessing psychological symptoms, no association was found in this study [13]. Analysis of morphological characteristics derived from PPG waveform could provide complementary information in quantifying depression and stress levels.

Although wrist-worn devices offer the opportunity for massive non-invasive screening, low signal quality and artifact movements may add substantial noise to any physiological measurement. This in combination with the lack of objective measurement of mental health symptoms may blur the association with the ANS function.

## V. Conclusion

Presented results suggest that higher stress and depression levels in first-line healthcare workers posed by COVID-19 are moderately correlated with higher PPG-based markers of arterial stiffness. In this way, PPG morphological characteristics could provide valuable information for assessing emotional and psychological disturbances.

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