

# Digital Eavesdropper: Acoustic Speech Characteristics as Markers of Exacerbations in COPD Patients

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**Abstract**—Research suggests that speech deterioration indicates an exacerbation in patients with chronic obstructive pulmonary disease (COPD). This study provides a comparison of read speech of 9 stable COPD patients and 5 healthy controls (I) and 9 stable COPD patients and 9 COPD patients in exacerbation (II). Results showed a significant effect of condition on the number of (non-linguistic) in- and exhalations per syllable (I, II) and the ratio of voiced and silence intervals (II). Also, sustained vowels by 10 COPD patients in exacerbation were compared with 10 vowels in stable condition (III). Results showed an effect of condition on duration, shimmer, harmonics-to-noise ratio (HNR) and voice breaks. It was concluded that HNR, vowel duration and the number of (non-linguistic) in- and exhalations per syllable show potential for remote monitoring. Further research is needed to examine the validity of the results for natural speech and larger sample sizes.

**Keywords**—COPD, lung exacerbations, pulmonary disease

## I. INTRODUCTION

### A. Speech and Speech Disorders

Each human language consists of a set of vowels and consonants which are combined to form words. During the speech production process, thoughts are converted into spoken utterances to convey a message. The appropriate words and their meanings are selected in the mental lexicon [1]. This pre-verbal message is then grammatically encoded, during which a syntactic representation of the utterance is built. The sounds are yet to be specified, but the abstract word symbols are assigned to their grammatical function before they are structured in a syntactic frame to determine the order [2]. Subsequently, the message is phonologically encoded. During this stage, a phonetic or articulatory plan is retrieved for each individual lemma and the utterance as a whole. Finally, the speaker produces the utterance according to the phonetic plan [3].

(COPD) by investigating which aspects of speech differ between COPD patients and healthy speakers and which aspects differ between COPD patients in exacerbation and stable COPD patients.

### B. Chronic Obstructive Pulmonary Disease

1) *Background*: COPD is an umbrella term used to describe progressive lung diseases characterized by airflow limitation. According to the guidelines provided by the Global Initiative for Chronic Obstructive Lung Disease [6, p. 2], the official definition of COPD is "a common, preventable and treatable disease that is characterized by persistent respiratory symptoms and airflow limitation that is due to airway and/or alveolar abnormalities usually caused by significant exposure to noxious particles or gases."

2) *Prevalence*: The prevalence of COPD worldwide is estimated at roughly 12%, but the percentage differs greatly between different subgroups [7]. Most COPD patients are suffering from stage II COPD (70%), while stage I, III and IV make up respectively 16%, 11% and 3% of the COPD population. The four greatest predictors of COPD are years and intensity of smoking, age, sex and BMI. Most patients suffering from COPD are smokers with a low BMI, over 50 years old and male [7].

Taking into account the three million annual deaths globally, COPD is currently the fourth leading cause of death in high-income countries and it is expected to be the third leading cause in 2020 due to a higher life expectancy and increasing air pollution [6, 8, 9]. However, the lung disease has been overlooked and neglected for a long time by both the public and the pharmaceutical industry. This neglect might be caused in part by the assumption that COPD is a self-inflicted health condition caused by smoking. Although smoking is the leading cause of COPD in high-income countries, over 15%

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