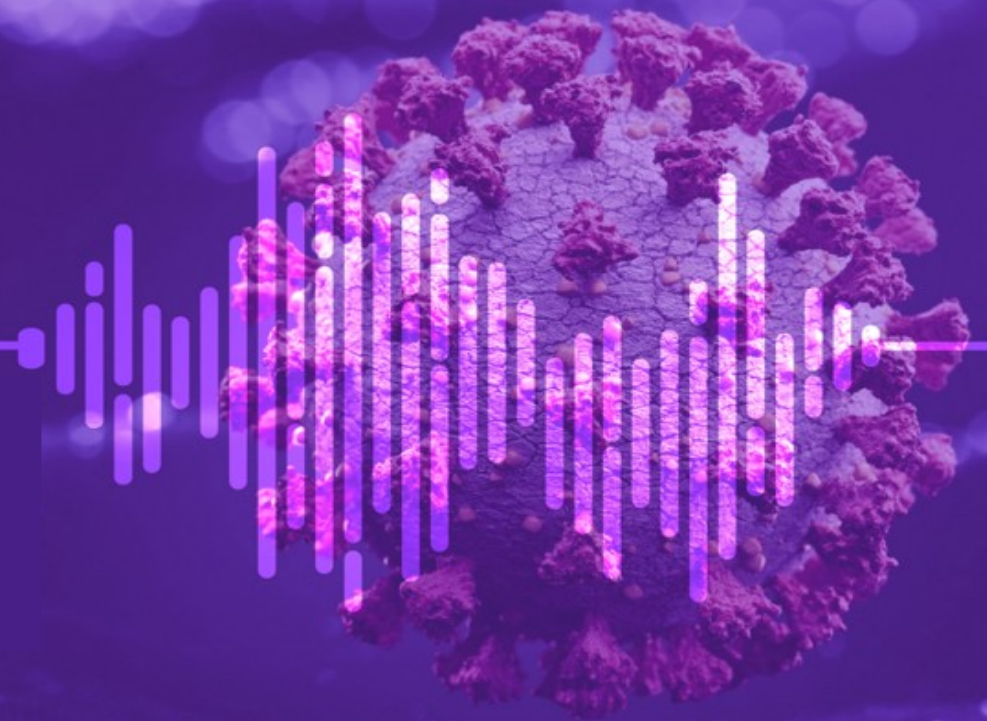


Estudo  
**SPIRA**

Artificial Intelligence for the  
Development of Audio  
Biomarkers and Remote  
Medicine



**Marcelo Finger – Coordinator, CS-IME-USP**

Universities - USP, UTFPR, UNESP

Computer Science, Faculty of Medicine, Linguistics and Letters, Mathematical Sciences and Speech  
Therapy



# SPIRA: System for Early Detection of Respiratory Insufficiency via Audio Analysis

## Why detect respiratory insufficiency?

Initial response of the Artificial Intelligence (AI) area to the COVID-19 pandemic

- Silent hypoxia, serious COVID-19 symptom
- But also: Influenza (H1N1), heart disease, lung problems, sleep disorders, anxiety attacks, etc.

## Idea

- Ester C. Sabino, FM-USP
- Anna Sara Levin Shaferman, FM-USP
- Marcelo Finger, IME-USP



# Project Start

- Approval from Ethics Committee (CEP-HC-FMUSP)
- Financing: Fapesp Project 2020 / 06443-5
- Organization of a multidisciplinary team
- Phase 1: Pandemic 1st wave. June/July 2020
- Phase 2: After vaccination started. July 2022- July 2023



# Project Organization: Phase 1

**Database construction:** speech as a biomarker, "wild" data

**Pre-processing of audio samples**

**Three investigative fronts:**

1. Prediction: **Big Data** Approach (Black Box)

2. Detecting Respiratory insufficiency with **Machine Learning**

3. Data description: **Small data** approach (White box)

4. Statistical description of respiratory failure in audio samples

5. Software development for data collection/prediction



# Initial Dataset Construction

## Covid19 Voices

Approx 600 samples HC+HU+BP



## Healthy Voices (Control)

Over 6000 voice donations



Collecting  
ward  
background  
noise



# Data Collection: Phase 1

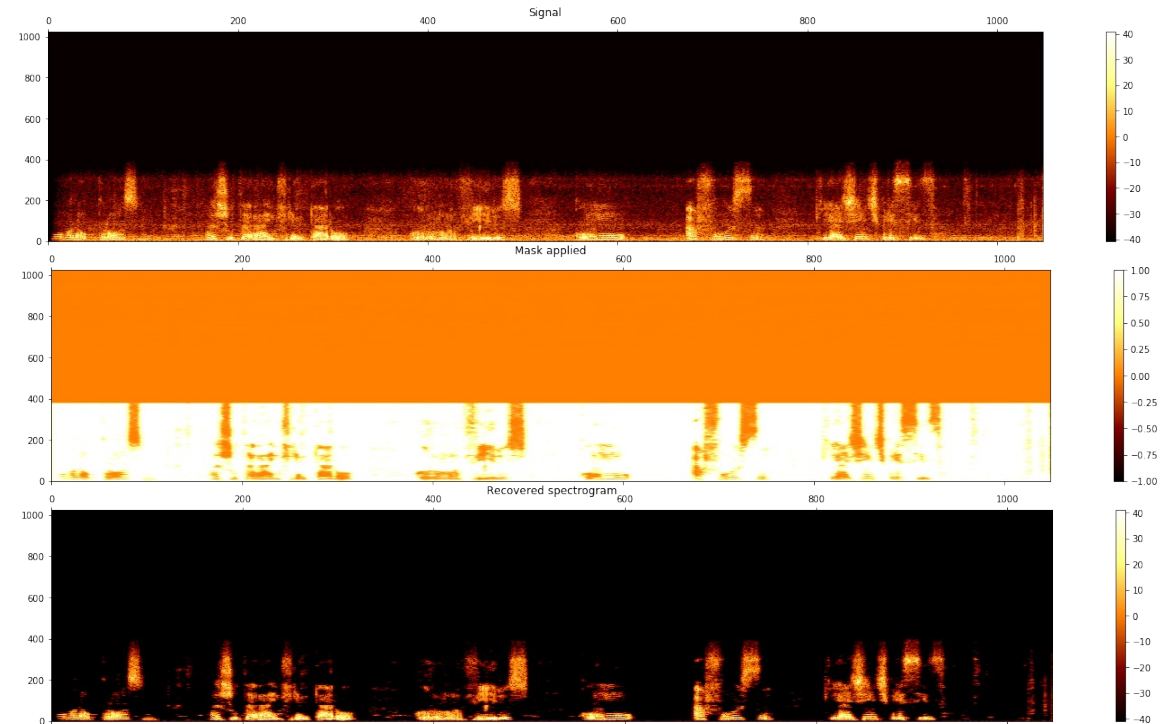
- Nurses and doctors unavailable (pandemic overload)
- Collection made by medical students or foreign medical visitors, coordinated by Dr Anna Sara Levin
- Cell phone use in COVID wards (no special equipment)
- Program via whatsapp (opus format)
- COVID wings:
  - Public university hospitals: Hospital das Clínicas, University Hospital
  - Private hospital: Beneficência Portuguesa
  - First wave of the pandemic (06-07/2020)



# Pre-processing

## Background bias

- Very noisy COVID wards
- Donations in “different” environments



## Would we lose information in sound filtering?

Need to compensate for bias due to background noise

Dilemma: **noise reduction vs noise insertion**

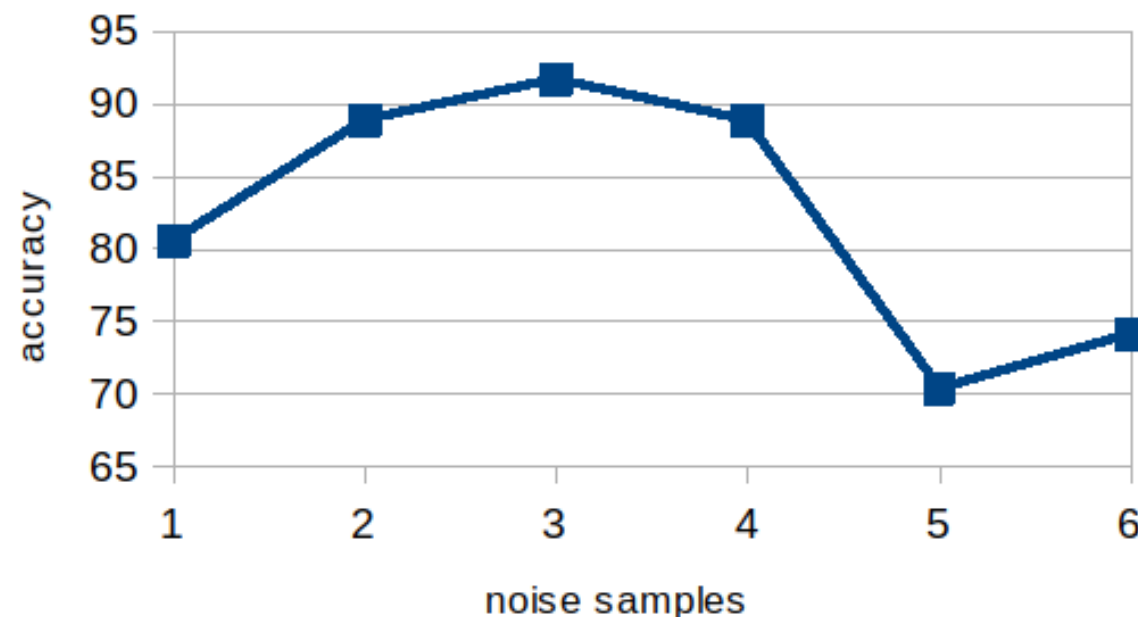


# Big Data: Results

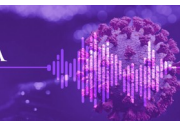
**Balanced data:** patient/control, gender, age

Technique for dealing with audio bias in "real" situations

- Neural networks over MFCC-grams
- Insertion of noise in patient and control data
- CNN Technique: Accuracy 91%



**Respiratory insufficiency can be detected in speech with 96.5% accuracy, using Transformers neural nets**





# Small Data: Signal Description

Two general hypotheses

- Pauses are longer in patients
- Most frequent vocal deviation in patients

**Results: Pause as a Biomarker for COVID-19:** First prize at the Brazilian Speech Therapy Symposium

**To do:** Identification of differences between patient/control groups:

- temporal measures
- prosodic measures
- spectral measurements



# Other Results

- INTERSPEECH Stefan Steidl Computational Paralinguistics Award, COVID-19 Cough Sub-Challenge Prize 2021.
- First Place: Speech Emotion Recognition in Portuguese, SE&R2022



## Second Phase

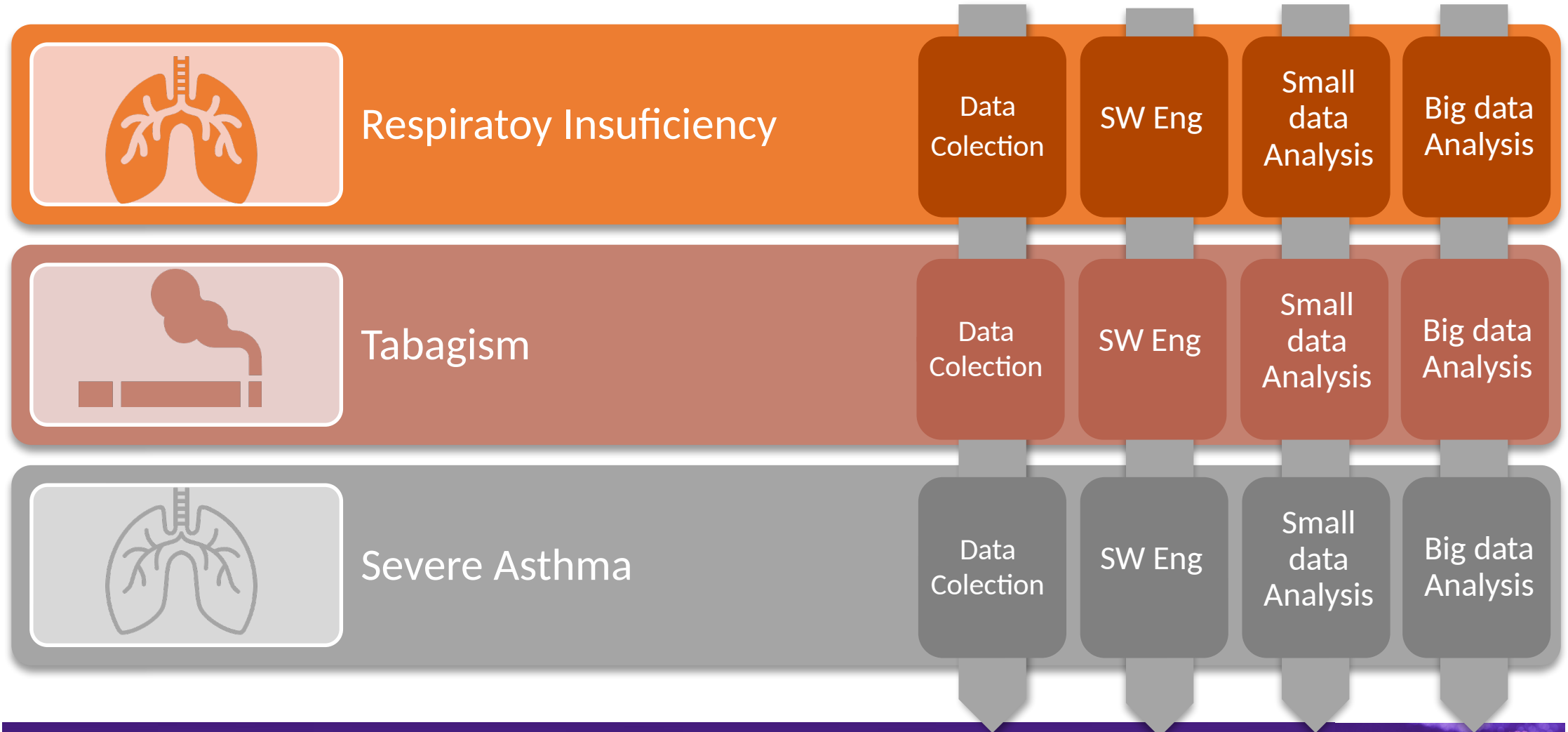
Second phase data collection (BP, UNIMAR, Sta Casa Marília):

1. General respiratory insufficiency
2. Influenza (H1N1), heart disease, lung problems, severe asthma, sleep disorders, psychiatric disorders, post-covid, etc.
3. IR source classification by machine learning
4. SpO2 prediction by voiceSegunda fase de coleta de dados (BP, UNIMAR, Sta Casa Marília)



# Project Sequel: Respiratory Biomarkers

Research Lines



# SPIRA-BM: Respiratory Insufficiency Audio Biomarkers

- Detection of RI from several etiologies (causes):
  - Heart condition, COPD, Influenza, Asthma etc, besides COVID
- Predicting the most probable etiology for RI
- Oxygen Saturation regression (SpO<sub>2</sub>)
  - Early results show this is harder than RI detection
- Clinical tests for AI tool



# SPIRA-BM: Tabagism

- Estimation of COex
  - Can exhaled CO be detected by audio analysis?
  - Gamification of Smoking Cessation
- Estimation of “Tabagistic Load”
  - Can we detect the number of years of smoking activity by audio analysis?
- Respiratory insufficiency due to smoking

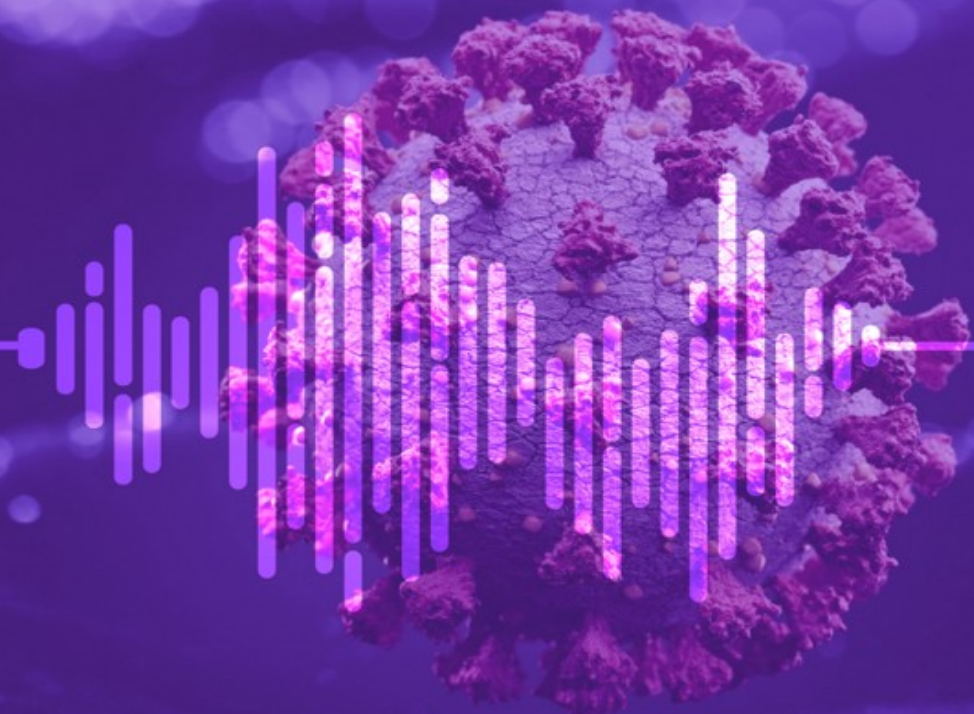


# SPIRA-BM: Severe Asthma

- Prediction of asthma exacerbation (attack) by audio analysis
  - Improve patient quality of life
  - Decrease costs due to hospitalization
- Can we predict an attack 48h before it occurs
  - Development of new therapies (respiratory physical therapies)
- Respiratory insufficiency due severe asthma



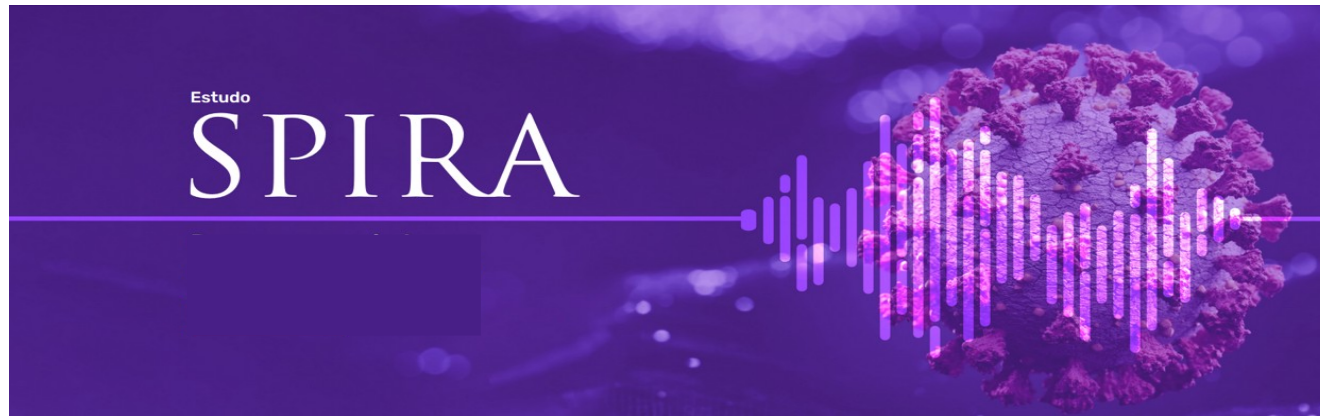
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## **Anunciando: Bolsa de Jornalismo Científico JC-3 da Fapesp**

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