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Automatic System for Detecting Pathologies in the Respiratory System for the Care of Patients with Bronchial Asthma Visualized by Computerized Radiography

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Abstract— COVID-19 is a disease that directly affects the respiratory tract, being harmful in asthmatic patients because this condition causes a lack of oxygen, even to the extent that it requires external equipment to combat drowning. Likewise, it highlights the importance of maintaining a treatment or therapy correctly to prevent your disease from worsening or being exposed to other diseases, putting your health at risk. The diseases that asthmatic patients can acquire can result from pathologies, which have been growing over the years due to lack of equipment or efficient examinations that generate complete information about respiratory conditions about asthmatic patients, therefore, by developing an advanced system, the chances of detecting pathologies prematurely increase considerably, which is an essential tool today. According to the problem exposed, in this research an automatic system of detection of pathologies in the respiratory system was carried out for the care of the patient with bronchial asthma visualized by computerized radiography, so that any pathology can be detected by means of a premature diagnosis in the respiratory system and the doctor can perform a correct treatment on the asthmatic patient. Through the tests carried out by the system, its performance was accurate and efficient, being suitable to be implemented in various hospitals so that the doctor can treat the disease in time, since the system presented a 98.79% efficiency in the detection of pathologies.

Keywords- Arduino, COVID-19, Image processing, Module, MATLAB, X-ray.

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I. INTRODUCTION

At present, there is already knowledge of the negative effects of coronavirus disease (COVID-19) on the health of people who managed to contract this pathogen that is largely contagious [1], presenting two common symptoms for all patients who are body warmth and problems breathing [2]. Likewise, this disease affected people of different intensity, some were able to control this infection based on medications [3], while other patients needed oxygen concentrator equipment because this infectious disease directly affected their respiratory system causing drowning problems. [4]

So, by complicating the airways it is completely risky in those patients with bronchial asthma due to the sensitivity of contracting this disease by COVID-19 and presenting problems to be able to breathe normally [5], therefore, it is important that asthmatic patients perform their therapy continuously to avoid any complication of their disease or against other diseases from which they could be prone to get sick and put their health at risk [6]. This disease of bronchial asthma is characterized by being the most difficult of all bronchopulmonary conditions because its main characteristic is chronic inflation in the bronchi, causing events of absence of air, wheezing and a perception of tightness in the chest [7], finding more than 400 million patients of different conjuncture worldwide. [8]

According to various medical research on bronchial asthma, in the coming years there will be a trend of increasing asthmatic patients, specifically in minors [9], being increasingly necessary to make a system that allows to effectively diagnose pathologies in asthmatic patients, because the methods to make an early diagnosis in patients such as sputum examination, the measurement of respiratory flows and volumes by means of spirometry, etc. [10], do not provide sufficient information to detect pathologies in bronchopulmonary affections even though they were developed for that purpose. [11]

By developing an advanced system for the detection of pathologies in the bronchopulmonary system, it certainly increases the possibility of detecting any pathology on patients early, likewise, increases the chances that patients receive early treatment and avoid any complications [12], in the same way, it will allow a prudent number of asthmatic patients to perform an early detection about the pathologies [13]. Now, the significance of being non-invasive is that it does not cause discomfort to the patient [14], so it would avoid any manipulation on the patient's body.

The objective of this research is to develop an automatic system for detecting pathologies in the respiratory system for the care of patients with bronchial asthma visualized by computerized radiography to detect any pathological change in the bronchopulmonary affections of patients. Its development is based on the use of transmitting and receiving antennas for the radiation of non-ionizing microwave signals connected next to a computer for image processing. The image will be processed by MATLAB by applying various processing techniques that will be developed during the research.

In section II, the literature review about developed research will be carried out. In section III, the methodology about the system will be carried out by developing a block diagram. In section IV, the way of carrying out the operation will be carried out to detect possible pathologies in patients. In section V, the results obtained from the system will be carried out. In section VI, the discussion of the system against other developed systems will be carried out. In section VII, the conclusion and recommendation of the system will be carried out.

II. LITERATURE REVIEW

Being a disease that is characterized by being the most difficult of all bronchopulmonary conditions, any pathological changes that patients may have that may complicate their health should be detected. For this reason, they must have the corresponding care using various tools. As, for example: In [15], the researchers mention that a few years ago the demand to diagnose diseases in the lungs increased markedly, specifically in patients with bronchial asthma, being limited by not using technologies as a tool for the detection of pathologies, applied maneuvers or pulmonary techniques that usually did not help much in giving complete information about the detection of pathologies and that by not having the certainty of diagnosis they could Making mistakes about patients, therefore, decided to develop a portable system for early detection of pathologies for children with pulmonary complications by means of images. The procedure of the researchers relies on the pulmonary ultrasounds of the patients for a previous analysis easily associated with the lung conditions to later apply the Fast R-CNN algorithm to the images of the minor patient, leading to the early determination of pathologies to prevent them from presenting respiratory problems over time, completely surpassing traditional techniques in the detection of single stage with characteristics. As a result, they presented an 88.70% efficiency in the detection of affections in patients, reaching the conclusion that the system works based on images without any external manipulation, making it a decisive and safe system.

In [16], researchers are based on the significance of finding respiratory pathologies early, specifically in elderly patients who have chronic asthma and that the part of their lungs are reduced so they can quickly present confusion when breathing, for this reason researchers seek to prevent these vulnerable patients from suffering alterations and can take a quality treatment by their trusted doctor so that he can help them of respiratory distress because their lungs are weak, they therefore decided to develop a premature system of pulmonary pathologies for elderly patients with chronic asthma by means of real images. The

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procedure of the researchers is based on the realization of a harassment to any change that may be in the lungs of the patient through the development of an algorithm that will interpret if the change is a pathological agent that can cause some complication over time, they rely on the ultrasounds taken from the patient and preprocessed in the algorithm developed in OpenCV in real time to visualize the pathologies. As a result they presented a 90.14% efficiency in the detection of respiratory pathologies in the elderly, concluding that their project works completely with images and does not need any physical maneuver, in addition to mentioning that it is safe.

In [17], researchers rely on the rapid identification of any pathology that may affect lung conditions by using various technologies, such as computed tomography, which is a tool that will facilitate the doctor in visualizing pathologies, as well as could reduce patient deaths because their analysis response is rapid, So it could be applied in asthmatics, to avoid that over time it can be related to lung cancer, which would undoubtedly affect patients to the point of causing death, therefore, they decided to develop an intelligent system to detect lung infections in asthmatic patients applied to improve diagnosis in radiologists. The procedure of the researchers focuses on the classification of lung infections, based on this, to be able to detect the pathologies that may occur in the pulmonary system of patients using lung ultrasound as a tool, then perform an image processing through Python to generate a more accurate vision for medical specialists when using this system that has a low percentage of error. As a result, they presented a 91.02% efficiency in detecting respiratory conditions in patients, concluding that their project works automatically and efficiently detects the conditions without any external manipulation.

In [18], researchers are based on the pulmonary complications suffered by asthmatic patients, which has been increasing due to lack of equipment or systems that facilitate the detection of pathologies in patients' lung conditions, likewise, they mention that an effective tool for rapid diagnosis is the application of the neural network, that according to their various applications, have generated positive results, as well as a low percentage of deaths in patients with lung conditions due to their rapid detection of pathologies, making doctors have a better diagnosis in their evaluation, therefore, they decided to develop a system recognizing asthmatic pathologies applied to the respiratory tract through tomography. The procedure of the researchers is based on applying a preprocessing to the images to improve the random variation of brightness and color, reducing any type of noise that may affect the image, after cleaning the image, they use a pretrained neural network to classify the images according to the pathology detected by the neural network, showing a broader diagnosis for doctors. As a result, they presented a 92.33% efficiency in detecting pathologies in the respiratory tract, concluding that their prototype uses a neural network that allows to accurately detect pathologies for a correct treatment of the patient.

In [19], researchers are based on the fact that in recent years lung diseases have been increasing every year, based on this, it has been taking center stage around the world by doctors. Based on modern technology, the researchers focused on a different way of being able to evaluate respiratory conditions through talk, in which through speech lung conditions could be diagnosed by segmenting the activity of the talk and its determined characteristics of the patients, therefore, they decided to develop a voice learning system for the detection of lung diseases in older adults. The procedure of the researchers is based on using a pretrained neural network so that it can develop the detection of pathologies in the respiratory tract through the patient's speech, at the time of interacting with the prototype it would be developing its own network that will classify and indicate if the older adult can present pathologies through 2 hidden layers to send it to a database. As a result, they presented a 93.6% efficiency in detecting pathologies, concluding that their system has a good performance in the detection of pathologies in affected patients.

III. METHODOLOGY

The methodology applied for this system is based on the exploration of the chest by means of an X-ray to detect pathologies that can affect the lung conditions of patients, in such a way that it is an advanced system that allows the doctor to have a broader and more accurate diagnosis. Taking into account these characteristics, a block diagram was developed specifying each process of the system, as shown in Figure 1.

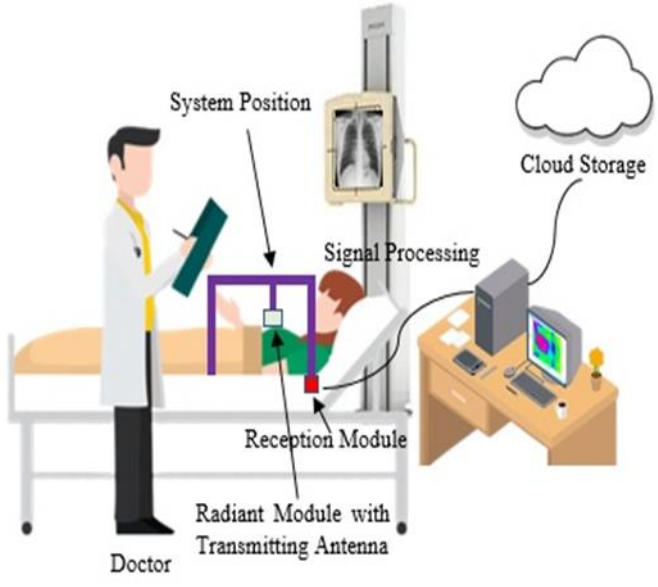

Figure 1. System block diagram

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According to figure 1, the automatic pathology detection system is based on the operation of a set of electronic devices, such as the microwave module, which by means of a transmission antenna will propagate the non-ionizing signals and through a receiving antenna the signal will be located to treat it and establish it with a defined intensity level to finally send the information to the computer and analyze it through MATLAB when processing and storing it on the server.

A. Microwave module

The stage of the microwave module (radiation) works with a non-ionizing signal and with a defined intensity level, this frequency in which it transmits the signal is conducted by a signal shadow that is reduced so that the electromagnetic chord with other mechanisms is not affected and several mechanisms can work at the same time and in the same bandwidth [20]. The operation of the microwave module can be seen in figure 2 by developing its diagram.

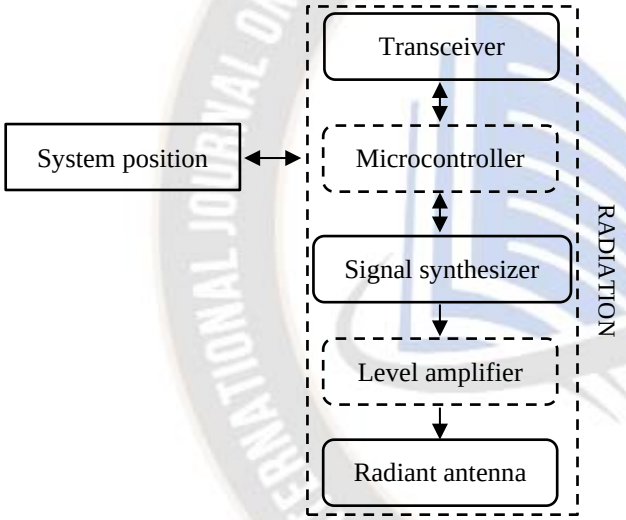

Figure 2. Diagram of the module microwave

B. Receiving antenna

The receiving antenna module, to receive and process the base signal of a digital fragment, the application of a filter for the analog fragment for the location of the signal and an array of forty components for the permuted antenna. The permutation of the components of the antenna array is determined based on the placement of the microwave module, therefore, the permutation of the array components is carried out by the digital fragment and the development of the signal, as well as the conversion of the identified signal and its main development for sending the information obtained from the measurement. The operation of the receiving antenna module can be seen in figure 3 by developing its diagram.

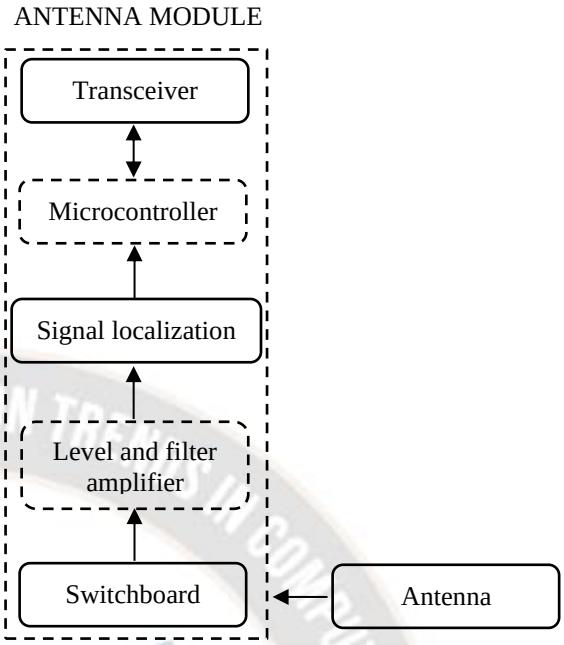

Figure 3. Diagram of the receiving antenna

The operation of the antenna module is based on the interconnection of various devices that allow the antenna module to receive the signal.

IV. DETECTION FUNCTION

The main reason for the analysis of the system is the performance of the location equipment that will automatically transfer to the microwave module through its aluminum rods connected to a motor, allowing the equipment to move perpendicularly. The location equipment is informed to the computer through a USB port, likewise, the results of the image treatment are processed through the module of the receiving antenna because it orders and transports the collected data.

The power supply for the location equipment is 20 volts in direct current, using a 28byj-48 motor that connects to the Arduino by means of an H bridge circuit to be able to control it without problems by means of the computer with its determined programming to control the motor automatically.

For the detection operation, a test was carried out on an artificial chest similar to that of patients with aspects of intrusive bodies, which will serve to ensure the operability of the system in specific tests with patients. For the appearance of pathologies in the artificial thorax, a transparent instrument containing a mixture of 0.89% NaCl with a variation of 80 ml was used, ensuring the performance of the system with a real situation by means of MATLAB.

The localization equipment that automatically moves to the microwave module by means of its rods does so with a growth of less than 1 mm, although this accuracy is not decisive due to the characteristics of its dimensions of the microwave module,

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which causes wider steps of 30 mm that produces greater clarity of shape and size of the mixture, Unlike a larger step, an irregularity of the mixture is generated and a smaller step increases the uniformity and requires more time. Likewise, the bandwidth used for computerized radiography with greater accuracy is based on 1250 MHz and 1350 MHz.

According to the analysis in MATLAB when using a transparent instrument containing a mixture of 0.89% NaCl with 80 ml applying steps of 30 mm and a bandwidth of 1250 and 1350 (MHz), it was appreciated that both separate the shape and size of the variety more clearly, as can be seen in Figure 4 and 5.

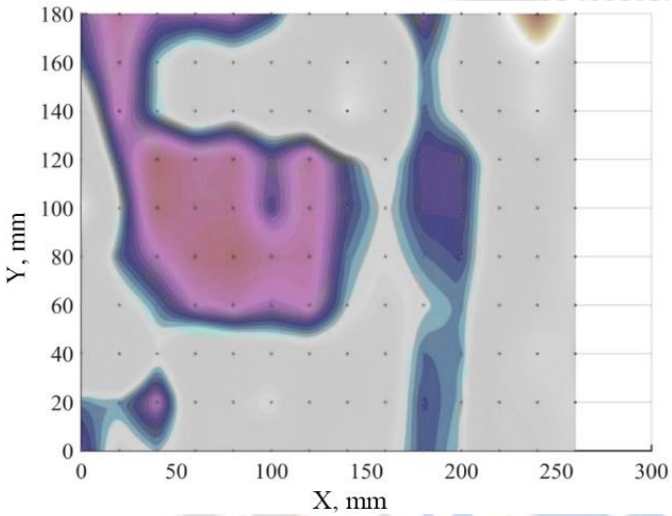

Figure 4. Treatment result at a frequency of 1250 MHz

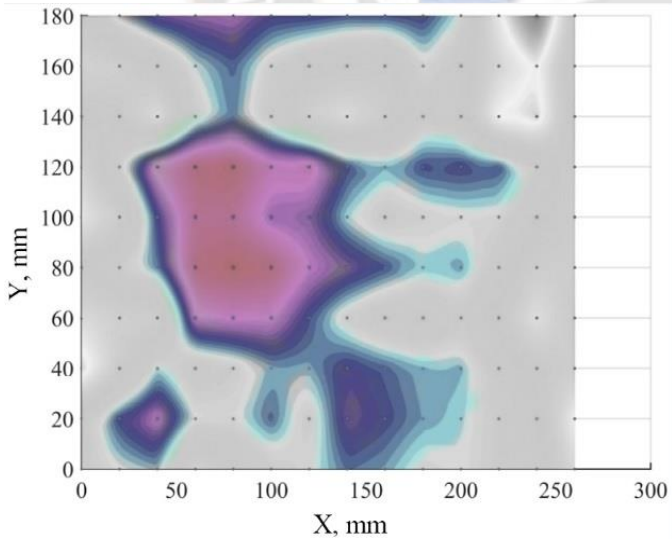

Figure 5. Treatment result at a frequency of 1350 MHz

Likewise, the tests were carried out with a higher bandwidth, and it was observed that the pathologies are not completely detected, complicating the reading to the doctor due to lack of accuracy in the characteristics of the pathology. Similarly, the tests were performed with a lower bandwidth than established and it was observed that the detection of pathologies is altered, so it would not help the doctor with the detection.

V. RESULTS

According to the development, the system shows results of its tests through graphs with inquisition about the distribution and density of the asthmatic patient's expectoration, allowing the doctor an easy evaluation about the pathologies that patients may acquire and combat it with time to avoid complications.

According to the development, the objective presented in the methodology is fully realized in order to detect pathologies in the respiratory conditions of patients. Therefore, when using the system in patients, any pathology that may affect the patient would be detected prematurely to evaluate it quickly by the doctor, likewise, in Table I the characteristics are appreciated.

TABLE I. SYSTEM CHARACTERISTICS

Automatic Detection System	
Power supply:	220v AC – 12v DC
Information acquisition:	By radiography
Bandwidth:	1250 - 1350 (MHz)
Image processing:	MATLAB
Detection Location:	Respiratory tract
Analysis time:	40 seconds
Accuracy:	98,79%

According to the development of Table I, the analysis of the patient is mainly based on the observation of the module in the part of the patient's chest, in a bandwidth of 1250 - 1350 (MHz) for a better visualization of the pathologies that the patient may have, treated by means of MATLAB for a more accurate visualization of diseases in the respiratory tract by means of a computerized x-ray.

According to the analysis carried out, the system performs accurately and efficiently, being suitable for use in various hospitals for patient care with the detection of respiratory diseases in a stable way, so the doctor can treat the disease with time, for this reason, it is a fundamental system in its operation that presented a 98.79% efficiency in the detection of pathologies.

According to the development of the system, few electronic components were used for the performance of the system, as well as the essential programming in MATLAB for the treatment of the image and visualize the detection of the pathology, likewise, the programming was carried out in Arduino to control the motor

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that displaces the microwave module, resulting safe for the patient and the doctor.

The localization equipment has the function of automatically transferring the microwave module on the patient by means of its rods, therefore, it was necessary to control the motor by means of an H bridge circuit, programmed in Arduino so that it moves accurately and without impediments.

VI. DISCUSSION

As there are various systems focused on the early detection of pathologies in patients, there are also various methodologies that are used to develop their final goal, with greater reason to contribute in the field of medicine because the cases of lung affections of patients have increased, therefore, many systems are needed to facilitate the detection of pathologies.

In addition, this system is based on applying unique techniques to detect pathologies in lung conditions to contribute to the area of medicine. Likewise, it differs from many systems developed previously because it applies a unique methodology, so it differs from other research, for example, the research carried out by [15], where researchers decided to direct a portable system of early detection of pathologies for children with pulmonary complications through images. Obtaining as a result an efficiency of 88.70%, but this system does not apply a complete analysis in the images, likewise, it lacks a preprocessing so that the algorithm can analyze the image without noise inconvenience.

The research conducted by [16], where the researchers decided to direct a premature system of pulmonary pathologies for elderly patients with chronic asthma through real images. Obtaining as a result an efficiency of 90.14%, but this prototype does not comply with the cataloging at the time of diagnosing the disease in elderly patients, leading to its results not being reliable. It was also observed that the researchers did not perform sufficient tests to determine its effectiveness of its operation and there was an irregularity in the tests.

The research conducted by [17], where the researchers decided to route an intelligent system to detect lung infections in asthmatic patients applied to improve diagnosis in radiologists. Obtaining as a result an efficiency of 91.02%, but this system due to its low sensitivity, can suffer from environmental interference and this can affect the results according to the evaluation of the patient. Therefore, this system can only focus with greater certainty in places of low fixation, to avoid that in the diagnosis it can evaluate patients as false positives in pathologies.

The research carried out by [18], where the researchers decided to direct a system recognizing asthmatic pathologies applied to the respiratory tract through tomography. Obtaining as a result an efficiency of 92.33%, but this system presents instability in the analysis of the images, even though they have used a preprocessing to improve the noise, its defect is observed in the result by the neural network, does not extend the classification of the pathologies, as mentioned in their results, but only analyzes asthmatic patients with initial stage.

The research conducted by [19], where the researchers decided to route a voice learning system for the detection of lung diseases in older adults. Obtaining as a result an efficiency of 93.6%, but this system develops a complex manipulation by the patient, showing information of the evaluation that does not allow to understand the patients by the difficult, likewise, they do not use a filter to avoid external interference for the sound. Next, a comparison observed in Table II of this system (a) with our developed system (b) will be made.

TABLE II. COMPARISON OF DETECTION SYSTEMS

	a	b
System	Automatic	Automatic
Information acquisition	By voice	By radiography
Image processing	No	MATLAB
Detection Location	Lungs	Respiratory tract
Accuracy	93,6%	98,79%

VII. CONCLUSION AND RECOMMENDATION

From the system it is concluded that its performance is essential, presenting the structure of an automatic system that performs the observation of respiratory conditions by means of a microwave module that emits a non-ionizing signal and with a defined level of intensity.

The system concludes that it presents a benefit of ease of manipulation, a low cost of implementation, a short time in detecting respiratory conditions in patients, as well as the non-performance of painful maneuvers on the patient.

The system concludes that it is completely safe, performs detection quickly, allowing no agglomeration to be generated in hospitals and helping to prevent any contagion of any viral disease that can spread quickly among patients.

From the system it is concluded that its performance is not dangerous when using the microwave module, because this module works in a bandwidth that is not dangerous for the patient's health, likewise, it makes the patient and the doctor are not locked in the office for a long time due to the current situation that is lived.

From the system it is concluded that the detection of pathologies in lung conditions is done automatically, without the

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need to be manipulated, it is only necessary that the doctor can examine the results and give his point of view regarding the detection that the patient may have.

From the system it is concluded that its implementation in various hospitals is totally feasible to help asthmatic patients avoid or treat in time any pathology that may affect them in the long term, so its development is optimal and does not present any limitation.

The future system can incorporate a sensor on vital signs of the asthmatic patient to measure body heat, heart rate, among other important information that allows us to know the status of the asthmatic patient for a complete diagnosis.

The recommendation of the system is that in its implementation it should be taken into account that the particularities must be respected, as well as the supervision of a doctor so that he can verify the results of the system.

REFERENCES

[1]. M. Adnan Shereen, S. Khan, A. Kazmi, N. Bashir, and R. Siddique, "COVID-19 infection: Emergence, transmission, and characteristics of human coronaviruses," *J Adv Res*, vol. 24, pp. 91–98, Jul. 2020, doi: 10.1016/j.jare.2020.03.005.

[2]. M. Schmulson, M. F. Dávalos, and J. Berumen, "Beware: Gastrointestinal symptoms can be a manifestation of COVID-19," *Rev Gastroenterol Mex*, vol. 85, no. 3, pp. 282–287, Jul. 2020, doi: 10.1016/J.RGMX.2020.04.001.

[3]. M. Palacios Cruz, E. Santos, M. Velázquez Cervantes, and M. León Juárez, "COVID-19, a worldwide public health emergency," *Revista Clínica Española (English Edition)*, vol. 221, no. 1, pp. 55–61, Jan. 2021, doi: 10.1016/j.rceng.2020.03.001.

[4]. Ó. L. Medina Espitia, F. Mendoza Beltrán, A. M. Anaya Almanza, and Ó. A. Molano Salazar, "COVID-19 and metabolism: a look beyond the respiratory system and thrombotic disease," *Revista Colombiana de Cardiología*, vol. 28, no. 4, pp. 366–373, Jul. 2021, doi: 10.24875/RCCAR. M21000067.

[5]. J. J. L. Sienra Monge, "COVID-19 and the asthmatic patient in the office," *CONAMED Magazine*, vol. 25, no. 1, pp. 24–30, 2020, doi: 10.35366/97345.

[6]. P. M. Buss and S. Tobar, "COVID-19 and opportunities for international cooperation in health," *Cad Saude Publica*, vol. 36, no. 4, pp. 1–3, Apr. 2020, doi: 10.1590/0102-311X00066920.

[7]. M. Román Rodríguez, L. Ginel Mendoza, M. Blanco Aparicio, M. Rodríguez Rodríguez, and M. Bárcena Caamaño, "What not to do in the therapeutic management of bronchial asthma. Delphi consensus recommendations for physicians who treat asthma," *Aten Primaria*, vol. 53, no. 7, pp. 1–9, Aug. 2021, doi: 10.1016/J.APRIM.2021.102101.

[8]. R. Calderón Villa and J. F. Tejera Concepción, "The bronchial asthma, an approach to this look in Cuba," *Revista pedagógica de la Universidad de Cienfuegos*, vol. 16, no. 76, pp. 15–23, Sep. 2020.

[9]. V. L. Soya, V. N. Lezana, and A. P. Silva, "Childhood Obesity and Bronchial Asthma," *Pediatric Pneumology*, vol. 14, no. 4, pp. 200–204, Dec. 2019, doi: 10.51451/NP. V14I4.113.

[10]. J. C. Vázquez García *et al.* , "E-health strategy to improve the diagnosis of COPD and asthma in Mexico's Primary Care," *Neumol Cir Thorax*, vol. 80, no. 1, pp. 11–18, Jan. 2021, doi: 10.35366/99449.

[11]. C. Chiesa, J. Lechien, and S. Saussez, "The alteration of smell and taste in COVID-19 patients. A diagnostic resource in primary care," *Aten Primaria*, vol. 52, no. 8, p. 592, Oct. 2020, doi: 10.1016/J.APRIM.2020.05.005.

[12]. M. A. Vences, C. Manrique Villegas, J. Mogollon Lavi, T. Arias Rojas, and F. Barriga Cari, "Critical asthma associated with allergic bronchopulmonary aspergillosis: case report," *Rev Peru Med Exp Salud Publica*, vol. 37, no. 2, pp. 367–370, Aug. 2020, doi: 10.17843/RPMESP.2020.372.4773.

[13]. J. Contreras Porta, F. Vílchez Sánchez, D. Loli Ausejo, A. Fiandor, and J. Domínguez Ortega, "When education in asthma is crucial. About a case," *Rev Alerg Mex*, vol. 66, no. 4, pp. 493–498, Sep. 2019, doi: 10.29262/RAM. V66I4.584.

[14]. D. Zambrana, V. Esteve, J. Vicente, and J. Sabater, "Non-invasive obtaining of the carotid blood pressure wave," *XL Jornadas de Automatica*, pp. 113–118, 2019, doi: 10.17979/spudc.9788497497169.113.

[15]. R. Bassiouny, A. Mohamed, K. Umapathy, and N. Khan, "Portable Early Pathology Detection System for Children with Pulmonary Complications by Means of Imaging," Proceedings of the *Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, pp. 3029–3034, 2021, doi: 10.1109/EMBC46164.2021.9630169.

[16]. I. v. Semernik, A. v. Dem'yanenko, F. S. Topalov, and Y. v. Nevstruev, "Premature Pulmonary Pathology System for Elderly Patients with Chronic Asthma by Means of Real Images," Proceedings of the 2019 *IEEE Conference of Russian Young Researchers in Electrical and Electronic Engineering, ElConRus*, pp. 1318–1322, Feb. 2019, doi: 10.1109/EICONRUS.2019.8657188.

[17]. G. Aresta *et al.* , "Intelligent System for Detecting Pulmonary Infections in Asthmatic Patients Applied to Improve Diagnosis in Radiologists' Screening Performance," *IEEE J Biomed Health Inform*, vol. 24, no. 10, pp. 2894–2901, Oct. 2020, doi: 10.1109/JBHI.2020.2976150.

[18]. H. Khachnaoui, M. Agrebi, S. Halouani, and N. Khlifa, "Asthmatic Pathology Recognition System Applied to the Respiratory Tract by Means of Tomography," 2022 *6th International Conference on Advanced Technologies for Signal and Image Processing (ATSIP)*, pp. 1–6, May 2022, doi: 10.1109/ATSIP55956.2022.9805929.

[19]. V. Nathan, K. Vatanparvar, K. S. Chun, and J. Kuang, "Voice-Learning System for the Detection of Pulmonary Diseases in Older Adults," Proceedings of the *Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBS*, pp. 1338–1341, 2022, doi: 10.1109/EMBC48229.2022.9871980.

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[20]. A. Sucasas Alonso, S. Pértega Díaz, R. Sáez Soto, and A. Ávila Álvarez, "Epidemiology and risk factors for bronchopulmonary dysplasia in preterm infants born at or less than 32 weeks of gestation," *An Pediatr (Engl Ed)*, vol. 96, no. 3, pp. 242–251, Mar. 2022, doi: 10.1016/J.ANPEDI.2021.03.002.