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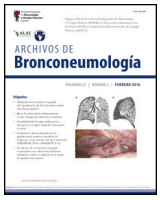

Scientific Letter

Analysis of Exposure and Respiratory Health Effects of Volcanic Eruption in the Canary Islands (ASHES). A SEPAR Study

To the Director,

Volcanic eruptions are a relatively rare natural phenomenon that can impact public health due to the inhalation of gases and volcanic ash. This impact is characterized mainly by the appearance of respiratory signs and symptoms in a healthy population[1,2] and by the exacerbation of symptoms in patients previously diagnosed with respiratory diseases.[3,4]

On September 19, 2021, a volcano in the Natural Park of Cumbre Vieja on the Canarian island of La Palma (Spain) erupted. It remained active for 85 days, spewing a constant stream of gases and ashes into the atmosphere.

Two factors made the eruption of this volcano a unique opportunity to study the effect of a natural phenomenon of this type: (1) the volcanic cone was located in close proximity to urban centers, so a large number of individuals were potentially affected; and (2) anthropogenic pollution levels (from road traffic or heating) on the island of La Palma are minimal, reducing the possibility of pollution emerging as a confounding factor.

Although the impact of eruptions on various aspects of health has been widely studied,[1,5–8] little is known about the potential effects in patients with respiratory diseases[9,10] or the possible medium-to-long-term respiratory consequences in healthy adults and children.[11]

The objectives of this study are to assess the short-, medium-, and long-term effects of exposure to volcanic ash and gases from the eruption on the respiratory health of 3 groups: the general population living in the affected area (adults and children); individuals subjected to high levels of exposure; and the population with previous respiratory diagnoses.

The ASHES (**A**nalysi**S** of Exposure and Respiratory **H**ealth **E**ffects of Volcanic **E**ruption in the Canary Island**S**) multi-design study, sponsored by the Spanish Society of Pulmonology and Thoracic Surgery (SEPAR) and developed by a multidisciplinary team of pulmonologists, epidemiologists, and environmental health experts, will soon get underway.

The characteristics, eligibility criteria, and sample size estimation of the different designs are described in Table 1. An ambispective cohort study will be conducted to analyze the effect of inhalation of gases and particulate matter from the eruption in both exposed and unexposed adult and infant populations, and a quasi-experimental before-after study will be performed in subjects with previous respiratory diagnoses.

The cohort study will recruit populations from both moderate-high exposure areas (municipalities of Los Llanos, Tazacorte, and El Paso) and low exposure areas (municipalities of Barlovento and San Andres y Sauces).

The quasi-experimental study will recruit patients with asthma, chronic obstructive pulmonary disease (COPD), and diffuse interstitial lung disease (ILD), and compare their last respiratory parameters and drug use retrieved from electronic medical records before the eruption with parameters obtained after the eruption period.

Six sources of information will be used: (1) personal interview; (2) biological samples: whole blood, serum, and urine; (3) respiratory tests: pulse oximetry, forced spirometry with bronchodilation, diffusion test and lung volumes, nitric oxide (FENO) test; (4) air pollution data: daily concentration and number of days that nitrogen dioxide, sulfur dioxide, ozone, and PM10 and PM2.5 particle concentrations exceeded the recommended levels. This exposure will be assigned to participants according to the data obtained at the closest geolocation point to their homes; (5) electronic medical record data: clinical parameters recorded at the date closest to the eruption (subjects with previous respiratory diagnoses only); and (6) imaging tests: (subjects with ILD or if clinically indicated).

Information from all these sources will be obtained from all patients (except 5 and 6, which pertain exclusively to subjects with a previous respiratory diagnosis). The information from the various sources will be collected at several time points, as shown in Table 2.

Two recruitment teams will carry out their tasks simultaneously, one in the area of moderate-high exposure and one in the area of low exposure. Each team will consist of 2 nurses, coordinated by the principal investigator, who will have access to all necessary equipment and infrastructure to conduct interviews, perform respiratory tests, and obtain biological specimens. These specimens will be properly stored in a sample bank for further analysis.

The study has received the approval of the Ethics Committee for Medical Research in the Complejo Hospitalario Universitario de Canarias, and participants will be required to sign informed consent, in compliance with legal requirements, granting access to electronic medical records in the case of patients with respiratory diseases. Parents or legal guardians will approve the participation of minors.

For cohort studies (in adults and children), a survival analysis will be performed for each outcome variable. Survival curves will be developed for each of the covariables using the Kaplan–Meier method, and the log-rank test will be used to compare these functions for the corresponding categories. Cox proportional hazards models will be developed for each outcome variable, adjusting for the different covariates. For the quasi-experimental study, generalized linear mixed models (GLMM) (or another appropriate test, according to the distribution of the outcome variable) will be applied to conduct a longitudinal analysis of the data (repeated observations over time for each of the study participants) by adjust-

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Table 1
Study design, population groups, inclusion criteria, sampling and sample size.

Population groups	Inclusion criteria	Sampling and sample size
Design 1. Cohort study in the adult population		
Group 1: High exposure -*Group 1a*: subjects who have been in the exclusion zone. -*Group 1b*: workers involved in cleaning up volcanic ash.	Age ≥ 18 years and <70 years. Continuous presence in the field of at least 1 month (group 1a). Professional involvement in clean-up tasks on the island during the eruptive period (group 1b).	*Group 1a*: 100 people who meet the inclusion criteria. *Group 1b*: All volunteers who meet inclusion criteria (estimated at 20 people minimum).
Group 2: Moderate exposure (municipalities of El Paso, Los Llanos de Aridane and Tazacorte)	Age ≥ 18. Registered inhabitants of the corresponding municipalities.	Convenience sampling. Recruitment centers: town halls, social centers, schools, pharmacies, local radio advertisements.
Group 3: Little or no exposure (municipalities of Barlovento, San Andrés, and Los Sauces)	Same place of residence since the beginning of the eruption or, if evacuated, accommodation in another municipality in the same exposure area	500 participants in each group.
Design 2. Cohort study in children		
Group 4: Pediatric population. -*Group 4a*: Pediatric population with high-moderate exposure -*Group 4b*: Pediatric population with little or no exposure.	Aged 6–18 years. Population residing permanently in the most affected municipalities (group 4a) and the least affected municipalities (group 4b).	Convenience sampling in educational centers. 300 children in the exposed area and 300 in the unexposed area.
Design 3. Quasi-experimental study		
Group 5: People with COPD, asthma or previous diffuse ILD, residing in the municipalities of El Paso, Los Llanos de Aridane and Tazacorte.	Age ≥ 18. Diagnosis of COPD, asthma, or interstitial disease in their medical history.	Sample universe. Posters will be placed in health centers, hospitals, pharmacies, municipalities and supermarkets in the areas of interest. Recruitment by respiratory medicine departments and primary care.

COPD: chronic obstructive pulmonary disease; ILD: interstitial lung disease.

Table 2
Time of collection of biological samples.

	Population group				
	Group 1 (high exposure)	Group 2 (moderate exposure)	Group 3 (low exposure)	Group 4 (children)	Group 5 (respiratory patients)
Interview	Start/Annual	Start/Annual	Start/Annual	Start/Annual	Start/Annual
Respiratory tests	Start/End	Start/End	Start/End	Start/End	Start/End
	Biological samples				
Whole blood	Start	Start	Start	Start	Start
Serum	Start/Annual	Start/Annual	Start/Annual	Start/Annual	Start/Annual
Urine	Start/Annual	Start/Annual	Start/Annual	Start/Annual	Start/Annual

ing for baseline values of the dependent variable, thus offering advantages over ordinary regression models.[12]

This study has certain limitations: it will not be possible to analyze the effect of the eruption on subjects with rare respiratory diseases. Moreover, quantification of the degree of exposure to volcanic gases and ash may be complex in certain contexts. Several factors will be taken into account to refine the data, such as distance from the volcanic cone, daily of air quality measurements, and personal habits (mask use and staying indoors), and the classification of subjects in 3 exposure groups will also indirectly reflect this variable.

However, the study also has some strengths: the particular features of this eruption, particularly the duration compared to other recent events,[2,5,8] means that the possible effects on respiratory health in the different population subgroups can be evaluated using the proposed cohort design.[2,11,13] From an epidemiological point of view, study subjects will be representative of the different exposure groups that will include respiratory patients, and the lost-to-follow-up rate is expected to be low. Finally, this research potentially offers the chance to study the molecular mechanisms that may be involved in the development of respiratory disease derived from exposure to eruptive material and the exacerbation of previous diagnoses.

This study, then, is a unique opportunity to advance knowledge of the health effects of natural disasters on the general population and to clarify the determinants and mechanisms of chronic respiratory disease aggravation.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.arbres.2022.04.012

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