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Article

A baseline study on mortality and air pollution in Kabyle village (northern Algeria) under COVID-19

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Abstract

The present work is a preliminary study of mortality data and fine particulate matter (≤ 2.5 µm, PM2.5) concentration in Kabyle village (northern Algeria) under COVID-19. Three epidemiological measures were used to quantify COVID-19-attributable mortality during the years 2019, 2020, 2021 and the first half of 2022, namely monthly death count, crude excess mortality (EM) and P-score (%). In addition, PM2.5 concentration was measured three times minimum in the morning (between 6:00 and 10:00 a.m.) for 2 to 25 days depending on the month, from August to October 2021 and from January to June 2022 to look for a possible correlation between air quality and monthly excess mortality. The P-score, as the most interesting parameter for comparison purposes, was found to range from approximately -67 % (in 2021, for women 65 years and older) to 133 % (in 2021, for men 65 years and older). For those under 65, the P-score is undefined, either because their EM is zero (the case in 2021 for men under 65) or because expected mortality is zero. The daily PM2.5 concentration varied from 0.5 to 150 µg/m3 during the entire observation period. A moderate positive correlation was found between monthly EM and monthly PM2.5 concentration, for women of all ages only (Kendall's tau (τ) ~ 0.22, p = 0.00). This work could inspire other larger studies, which should include, for example, all the 23 villages of the municipality, considering other air pollution parameters with, in addition, a more consequent recording frequency.

Keywords: *correlation, COVID-19, mortality, PM2.5, Kabyle village*

INTRODUCTION

The COVID-19 remains probably the most disastrous pandemic known to date in terms of negative impact on the health system as well as on socio-economic activity [1]. There is, however, a great spatial variability in COVID-19 mortality on which many risk factors, including PM, especially PM2.5 concentration are often incriminated [2].

Depending on the site, various sources are identified to generate PM2.5, namely vehicle traffic, dust resuspension, biomass burning, sea salt, industrial emissions, etc [3]. By becoming aware of these particle generators and of the harmful effects of PM2.5 on health, it becomes possible to act accordingly [3]. This said, each type of PM, of a different nature, acts differently on the human body [4]. Despite this, the role of the ambient air quality in COVID 19 mortality risk remains under-researched [5]. The existing literature highlights associations between air pollution and the spread of COVID-19 and COVID-19-related deaths. However, as noted by Bobilla et al. [6], most of these studies focused on developed countries. These authors found that in four countries of Latin America (Brazil, Chile, Colombia, and Mexico) that have been highly affected by the pandemic, an increase in long-term exposure of 1 µg/m3 of PM2.5 is associated with a 2.7 percent increase in the COVID-19 mortality rate. Just for comparison, this value is 4 times lower than that found by Wu et al. [7] for United States, which raises the still debatable question of the link between the severity of this pandemic and the level of development. In this vein, it is now well established that Africa was relatively and unexpectedly less impacted by the COVID-19. Various explanations have been put forward [8]: COVID-19 testing capacity, substantial young population, favorable climate, sound community health care systems proposed, etc.

The great danger of small particles (<10 µm) for health lies in their ability to penetrate the lungs and even diffuse throughout the human body by passing through the bloodstream [9]. Thus, PM2.5 can cause brain damage, by passing through the lungs and intestines and/or directly penetrating brain tissue via the olfactory nerve [10]. These risks are even greater in developing countries. Indeed, 98% of the population of poor and developing countries (against 56% in developed countries, which is already considerable) live in areas that do not comply with WHO air quality guidelines [11]. For example, it has been found that in the northeastern United States, populations with a low socioeconomic position are exposed to a higher level of PM [12], indicating a certain incongruity between eco-friendly lifestyle and economic growth.

Algeria has experienced four waves of spread, the third in the summer of 2021 being the most deadly with about 50 deaths per day [13]. However, no data on COVID-19 mortality in rural villages are reported in the literature, knowing that the impact of COVID-19 on all-cause mortality is particularly apparent when data are analyzed from small communities [14]. In this framework, investgating the relationship between COVID-19 mortality and PM2.5 in rural and medium-size municipalities, Páez-Osuna et al. [15] found that the exceptionally high COVID-19 mortality rates of the rural municipalities could be associated to dust events, when soils without vegetation are dominant. For their part, Bielska et al. [16] suggest focusing on rural and suburban areas as recreational destinations to restore the mental and physical health under pandemic conditions. In addition, these authors proposed Recreational Potential Index for evaluating the recreational potential of the area.

The present work describes for the first time, to our knowledge, a baseline study on excess mortality and air pollution in a Kabyle village (northern Algeria) under COVID-19.

It might be worth pointing out that, up to a certain moment, a typical kabyle village is a specific micro-ecosystem that combines the presence of mountains, forests and small farms, with the absence of industrial pollution, major highways and large residential buildings. These are probably the reasons why, whether consciously or not, the Kabyle diaspora living abroad often preferred to return to the land of their birth for summer vacations or as a place to live in retirement. It's probably these factors, and others linked to history, that have led the inhabitants of the Kabylie region to develop a strong bond with the mountains, nature and the land [17]. Today, like everywhere else, the Kabyle village is suffering the negative effects of globalization and changing consumption patterns in terms of household waste management. On this subject, a communication was devoted to domestic waste and toxic fumes in the context of a Kabyle village [18]. In addition, due to chemical transformations and atmospheric dynamics, air pollution is not confined to highly urbanized regions, but also occurs in rural and remote areas [19]. This situation is even more problematic during the COVID-19 crisis, which is primarily a lung disease. These are the factors that motivated the present study.

MATERIALS AND METHODS

Study site

The mortality and air quality data refer to the Tazerouts village (Fig.1), located in the Bouzeguène municipality, about 60 km southeast of Tizi-Ouzou (regional administrative center, 100 km east of the capital Algiers). The municipality has 23 villages spread over a geographical area with a very variable relief; approximately, the lowest village is at an altitude of 600 m and the highest is at 1000 m. According to our own estimates, the village currently considered as a study site is located at an altitude of around 800 m and has a population of about 850. The two genders each represent 50% of the population. Those under 65 years of age account for 80% of the males and 75% of the females. In these demographic data, which were counted in March 2022, emigrants and immigrants were excluded, including people who only spend weekends and vacations in the village. Deaths involving these categories were not also counted in this study. On the other hand, the citizens of the village who live in the territory of the municipality have been taken into account.

Fig. 1. General view of Tazerouts village as study site (foreground) and PM2.5 measurement point

Only two age categories (under 65 and 65+) were considered because it is well recognized that people aged 65 and over are the most affected by COVID-19 death than those under 65 [20].

Collection of mortality data

The mortality data was collected by continuous observation during the years 2019, 2020, 2021 and the first half 2022. The monthly death counts, monthly EM and annual P-score by age and gender were considered. The last two were calculated as follows:

EM (death number) = Observable Deaths – Expected Deaths (1)

P-score (%) = 100.EM/Expected Deaths (2)

For comparison purposes, the P-score is obviously the more interesting tool. However, the P-score may be undefined when the denominator value is zero and when both the numerator and denominator values are both zero.

Deaths registered in 2019 are taken as expected deaths, based on the fact that the COVID-19 appeared in Algeria in February 2020. In this context, Barnwal et al. have studied excess mortality in rural villages in Bangladesh in 2020 using 2019 as a baseline [21].

PM2.5 measurement and PM2.5-monthly EM relationship

The PM2.5 concentration was measured three times minimum in the morning (between 6:00 and 10:00 a.m.) for 2 to 25 days depending on the month, from August to October 2021 and from January to June 2022, using the experimental setup of Figure 2.

The Nova sensor includes a built-in fan and use a light scattering to measure the concentration of PM2.5 within the range 0.0 to 999.9 µg/m^3 with an average accuracy of 90 % according to the relative humidity [22].

The measurements were taken at a height of about 6 m from the ground, at a fixed site located at the lowest level of the village studied. Besides dust, fumes are the main source of air pollution in the area. They are produced by the incineration of waste by the households, by the collective dump of the studied village or finally by the collective dumps of the nearby villages. These incinerations often take place in the morning.

The comparison of daily average PM2.5 concentrations between months was performed using the non-parametric Kruskal-Wallis H test, whereas the association between these concentrations and monthly EM was assessed using the Kendall's tau (τ) [23], which is a nonparametric measure known to be more robust than a Spearman rank correlation [24].

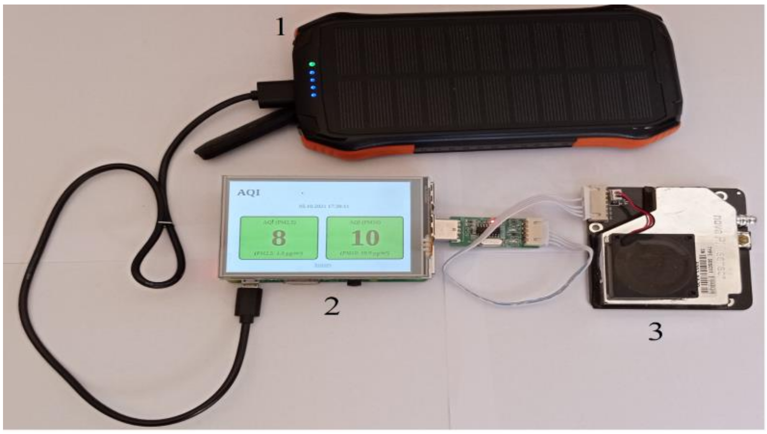

Fig. 2. Photo of the set-up used for the air analysis: 1- Solar battery (WBPINE Model N° F16SL), 2-data logger (KCEMC1 1728-94V-OF1-H4) with display (3.5inch RPi Display), and 3-PM2.5 and PM10 sensor (nova PM sensor, type SDS011) with USB stick (USB2TT-004)

RESULTS AND DISCUSSION

Analysis of mortality data

All obtained results are shown in Figure 3.

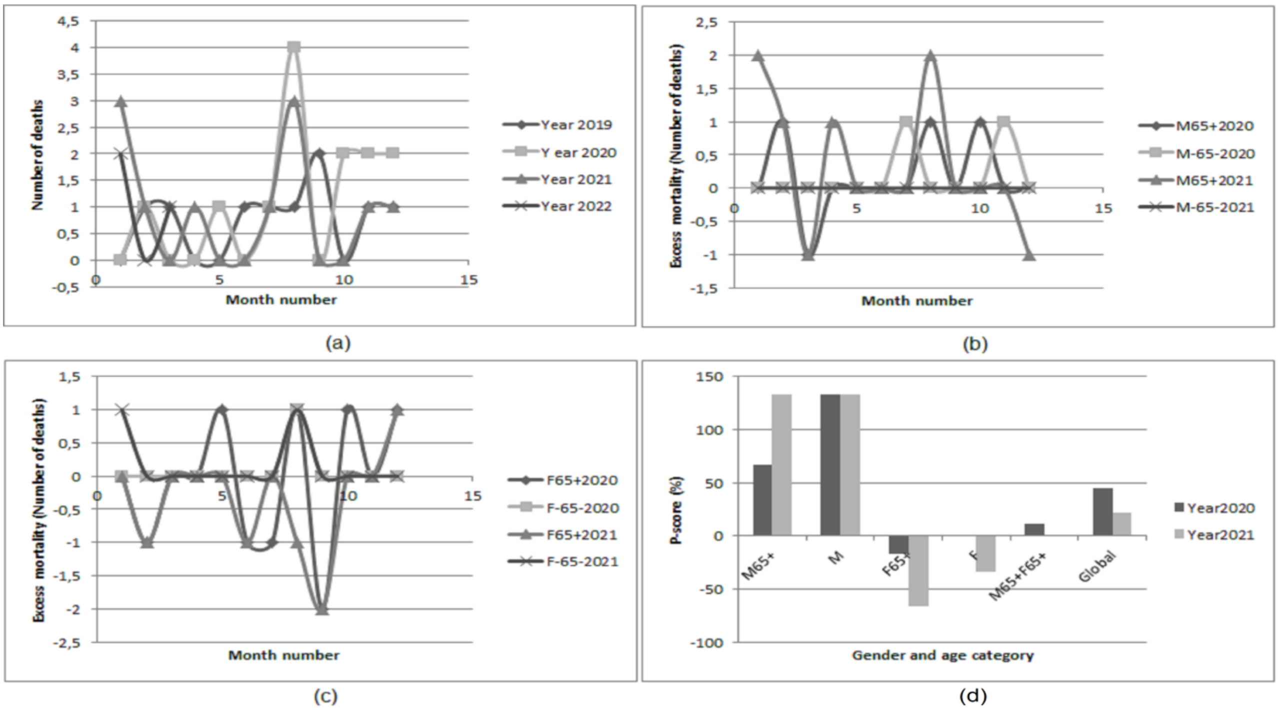

Fig. 3. Monthly death counts (a), monthly excess mortality of males of all ages (M) (b), monthly excess mortality of females of all ages (F) (c), and annual P-score (d), during the years 2019, 2020, 2021 and 2022 (case of monthly death counts)

As can be seen, the highest monthly number of deaths (4 deaths) was observed in August 2020 and then in January and August 2021 (3 deaths) (Fig. 3a). The August 2021 mortality peak coincides with that (41 deaths) observed nationally during the summer of 2021 [25], period marked by the deadliest third wave of COVID-19 in Algeria [13]. In terms of EM by gender and age, the highest values were found for men aged 65 years and over, compared with men under 65 years (Fig. 3b) and women of all ages (Fig. 3c). The P-score, as the most interesting parameter for comparison purposes, was found to range from approximately -67 % (in 2021, for women 65 years and older) to 133 % (in 2021, for men 65 years and older) (Fig.3d). For those under 65, the P-score is undefined, either because their crude excess mortality is zero (the case in 2021 for men under 65) or because expected mortality is zero. These findings are consistence with literature data. In fact, it is already well established that people aged 65 years or older have a higher rate of death from COVID-19 than younger people, and that men have a higher risk of death from COVID-19 than women [26].

PM2.5 values and PM2.5-EM relationship

The measured PM2.5 concentrations are illustrated in Figure 4.

As can be seen, there is a large variability in PM2.5 concentration values with a minimum and maximum daily concentration of 0.5 µg/m^3 (recorded in April 2022) and 150 µg/m^3 (recorded in June 2022). The Kruskal-Wallis H test indicated that there is a significant difference in the daily PM2.5 concentrations between the different months (χ^2 = 19.14, p <0.05). As underlined above, these fluctuations are essentially due to the fumes produced by the incineration of waste by households, by the collective landfill of the village studied or finally by the collective landfills of neighboring villages. In fact, the problem of domestic waste and toxic fumes in the context of a Kabyle village has already been raised [18]. From Figure 4, the mean concentration of PM2.5 exceeds the threshold limit (15 µg/m^3 per 24 h) recommended by the World Health Organization (WHO) during the months of May and June 2022 [27], while extreme values exceed this threshold since January 2022.

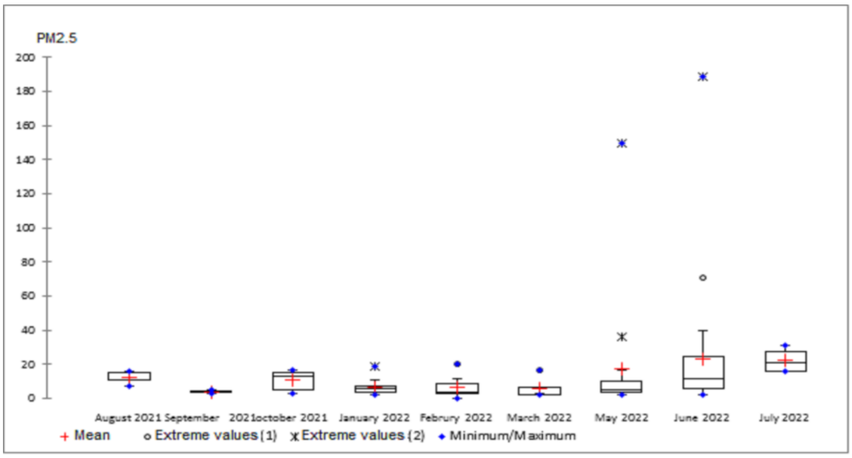

Fig. 4. Box plots of PM2.5 concentration (µg/m^3) during the studied period. Data for July 2022 were added for informational purposes but not discussed, being obtained with another instrument

Under the conditions described here, the extreme values are not outliers but they correspond to pollution peaks generated by the combustion of a finite and well determined mass of waste. This being so, the maximum PM2.5 concentrations obtained are at least two times lower than the daily maximum values (about 80 µg/m^3) concerning some sites of Algiers city in 2015 and 2016 [28].

The results of Kendall's tau (τ) test are summarized in Table 1. These data indicate that there is a moderate association between PM2.5 concentration and EM value only for females under 65 years of age (τ = 0.25, p = 0.00) and females 65 years of age and older (τ = 0.21, p = 0.00). Our opinion is that women are the most exposed to toxic particles because they are often the ones who manage the incineration of household waste.

Table 1. Kendall's tau (τ) correlation analysis

Correlation type	τ	p	95% CI
PM2.5/M65-EM	N/A	-	-
PM2.5/M65+EM	0.25	0.08	[-0.1065, 0.6157]
PM2.5/F65-EM	0.25	0.00	[0.2357, 0.2357]
PM2.5/F65+EM	0.21	0.00	[0.2166, 0.2167]

N/A = Not applicable because the values of the crude excess mortility (EM) are almost all zero.

These results are in line with some of the data in the literature, women being known to be often the most exposed to chemicals [29]. Indeed, in many countries, domestic tasks such as open-air waste incineration are carried out by women, with all that this implies in terms of risks not only for the woman herself, but also for the child's development during pregnancy [29].

CONCLUSIONS

The COVID-19 mortality in the studied Kabyle village (northern Algeria) differentially impacted the different age and gender categories. This impact appears to be moderately influenced by PM2.5 concentration.

This work, in its environmental aspect, could inspire other studies of larger scale. These should include, for example, all the villages of the municipality and/or the region, considering other air pollution parameters (PM 1, PM10, CO_2...) and their relations with other pathologies.

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