

# Impact of COVID-19 Pandemic on Aircraft Noise Levels, Annoyance, and Health Effects in an Urban Area in Oman

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# Abstract

This study aimed at investigating aircraft noise exposure levels, their annoyance, and potential health effects among communities living within airport catchment areas during the COVID-19 pandemic. Both field measurements and an online survey approach were used to investigate aircraft noise exposure levels, annoyance, and general health effects among residents living near Muscat International Airport (MCT) in Muscat, Oman amid COVID-19 period. The study found a drastic decline in aircraft noise levels due to the introduction of COVID-19 intervention measures such as lock-downs, social distancing, and closure of airports. In June 2020, during the COVID-19 pandemic average daily aircraft noise levels of  $L_{Aeq}$  (39.9 dB(A)) and  $L_{max}$  (49.7 dB(A)) was observed compared to the previous year (April-May 2019) of 58.5 and 76.8 dB(A), indicating aircraft noise reductions level of 32% and 35%, respectively. The results of the online social survey among 187 participants showed that most (58.8%) of the respondents did not feel that the level of noise produced by aircraft causes annoyance. During the day, the vast majority of the interviewees did not complain of any annoyance during the morning (45.5%), afternoon (39.6%), and evening (31%) with only < 4% of residents having reported a very high degree of annoyance of during COVID-19 pandemic period. Very few people (17%) did complain of experiencing general health problems while 29% did not know of any potential health effects that could be attributed to aircraft noise exposures. These findings support the need sustainable mitigation of aircraft noise in order to help improve health.

## 1. Introduction

The outbreak of human-human severe acute respiratory symptom coronavirus 2 (SARS-CoV-2) was initially reported in Wuhan city, Hubei Province, the Republic of China on 31st December 2019 (Chan et al. 2020). Since then, the SARS-CoV-2 has spread through almost every country within all the major regions/continents across the globe. As of 7 June 2020 in 10:15 GMT, the number of confirmed deaths caused by this virus was observed in Americas (183,999), Europe (178,761), Asia including Middle East (34,587), and Africa (5,089), whereas these mortality cases also correspond to the same order of total confirmed cases found within each region (WHO 2020; Worldometer 2020).

The health and economic impacts from COVID-19 pandemic have been exacerbated mainly due to the introduction of stringent lockdown measures by several countries which have ultimately affected the global business cycles (Guan et al. 2020; Ozili and Arun 2020). Fortunately, the COVID-19 lockdown and social distancing measures have positively impacted environmental pollution levels through a reduction in air pollution, water pollution, and flooding situations in most countries (Lokhandwala and Gautam 2020; Muhammad et al. 2020). Several studies have reported a decrease in ambient air pollution levels during the COVID-19 lockdown. A study found that the air quality index (AQI) of various cities in China has decreased by 6.34 leading to a reduction in  $PM_{2.5}$  levels by  $7 \mu g/m^3$  (He et al. 2020). In India, which is rated as one of the highly polluted countries, it was found that there has been a reduction in AQI index by 31–54% among the PM,  $SO_2$ ,  $NO_2$ , CO,  $O_3$ , and  $NH_3$  in Delhi during COVID-19 lockdown. Similarly, Madrid

and Barcelona experienced a significant reduction in ambient air quality by 62% and 50%, respectively where the study recommended the implementation of new air quality policies to help to achieve cleaner cities in the future (Baldasano 2020). Also, Saudi Arabia has reported a remarkable improvement in ambient air quality levels in the Eastern Province of the country where NO<sub>2</sub>, the marker for traffic emissions, reduced drastically during (12–86%) and after the lockdown (14–81%) periods (Anil and Alagha 2020). Concerning water quality, unfortunately, they may be the likelihood SAR-COV-2 transmissions during collection, treatment, and distribution of water in mega-cities such as in India including other developing countries where sewage treatment facilities are limited (Bhowmick et al. 2020).

On the other hand, the lockdown has led to an improvement in water quality levels of many polluted rivers in many cities by elevating the water quality levels from a poor state to a cleaner form where it can be used for both drinking and other domestic (e.g. bathing) activities due to decrease in pollution levels and sources of these water bodies as a result of the COVID-19 pandemic (Selvam et al. 2020). For example, the lockdown has reduced waste pollution across beaches, resuscitated the coastal ecosystems including improvement in human activities such as noise pollution levels due to a reduction in beach-related business activities (Yunus et al. 2020). It is widely known that COVID-19 pandemic has affected the aviation industry due to the closure of several airports across the world. This has greatly affected the mobility of many travelers and has also caused an economic loss to thousands of aviation industries. Fortunately, the COVID-19 pandemic measures especially the closure of airports have led to huge reduction in aircraft noise pollution levels among populations living closer to airport areas (Iacus et al. 2020a; Suau-Sanchez et al. 2020). Previous studies showed that noise levels produced by aircraft traffic were associated with increased in acoustic discomforts including annoyance, irritations, anxiety, and sleep disorders (Beutel et al. 2016; Brink et al. 2019; Lechner et al. 2019; Quehl et al. 2017). A cross-sectional study on the impact of aircraft noise exposures involving a total of 400 adult population of 45–70 years of age was carried out in Italy (Carugno et al. 2018). It was reported that annoyance levels among residents (65–76 dBA) living closer to the airports were doubled compared to those individuals (60–65 dBA) in far distant areas. Also, complaints about sleep disorders were found to be 36% and 30%, among the residents of areas closer to the airports and far distant areas, respectively (Carugno et al. 2018). A meta-analysis study comprising of more than 16,000 residents found an association with aircraft noise levels and an increase in the incidence of hypertension, especially among women and those with more than 55 years of age following the sub-group analysis (Huang et al. 2015). It was concluded that aircraft noise levels could lead to the prevalence of cardiovascular diseases (Huang et al. 2015). Similarly, there has been evidence of an increase in hospital admissions (Correia et al. 2013) and symptoms of cardiovascular diseases as a result of frequent exposure to high aircraft noise levels (Azuma and Uchiyama 2017). There have been situations of increased in symptoms of heart diseases and the incidence of stroke among people living closer to airports in many European countries following long-term airport noise exposures (Floud et al. 2013).

Over the decades, populations especially those dwelling near airports' areas were continuously exposed to noise levels with their attendant annoyance and health-related problems (Evrard et al. 2015; Eze et al. 2020; Franssen et al. 2004; Hansell et al. 2013; Lefèvre et al. 2020). Thus, no study has assessed so far aircraft noise levels, annoyance, and health effects over several months during airport closures from the COVID-19 pandemic. Considering the effect of noise on the health and well-being of the exposed population, it is crucial to evaluate the degree of noise exposure levels among resident populations living nearer to airport areas as a result of the impact of COVID-19 lockdowns and social distancing measures. This study aimed to assess aircraft noise exposure levels and the extent of annoyance among residents living closer to Muscat International Airport (MCT), in Oman amid COVID-19 pandemic period. In doing so, both field measurements and online social survey approaches were employed to respectively, estimate noise and annoyance levels among the exposed population. It is believed that these studies could provide background noise data for future noise mitigation measures which could aid in addressing the burden of noise-related health problems. Furthermore, the study outcomes could be used as a proxy in understanding aircraft noise pollution and annoyance levels in other countries across the globe during the current COVID-19 pandemic period.

## **2. Research Data And Methodology**

### **2.1 Study Area**

This study was conducted in the As-Seeb district area within Muscat Governorate, Sultanate of Oman. As-Seeb City has a total resident population of 463,960 people representing more than 32% of the entire population of Muscat (~ 1.42 million) (NCSI 2020). The climate in As-Seeb is characterized by short winter (December–February) and long summer (June–September) seasons with average ambient air temperature ranging from 16.7°C to a maximum of 40 °C, respectively. Rainfall is rare and normally occurs in winter with a maximum level of 16.5 mm, however, outdoor humidity levels has always been consistent at 15% to > 90% depending on the season (DGM 2020). As-Seeb is one of the major commercial and business hubs of Oman due to its closer proximity to the Muscat International Airport (MCT) making it one of the hotspots of high aircraft noise impacted areas in Muscat (Al Harthy 2007). The detailed description of the study area including measured noise locations and MCT is shown in Fig. 1.

### **2.2 Data**

#### **2.2.1 COVID-19 Status**

Following the SAR-CoV-2 virus outbreak in Wuhan city of China, Oman reported its first two (2) COVID-19 cases in Muscat on 24th February 2020 due to previous travels from Iran. On 25th March 2020, MCT was closed for commercial scheduled flights except for exempted activities such as medical supplies, evacuations of Omani citizens, etc. However, after 5th April, the country started experiencing a rapid increase in the daily number of COVID-19 cases in its major cities especially in Muscat including As-Seeb.

These high cases led to more stringent interventions such as lock-downs, closure of schools and mosques, implementation of social distancing measures, reduction in the number of workers by 30%, and implementation of wearing a facial mask in all public places (Khamis et al. 2020). As of 14th September 2020 3:32 PM CEST, the total confirmed cases of Oman remain 89,746 with > 93% recoveries. The number of COVID-19 deaths and sick people currently remains at 780 and 5195 cases (<https://covid19.who.int/region/emro/country/om>), respectively according to the Oman Ministry of Health (2020) and WHO (2020) as in June 2020. Table 1 shows the top-six (6) governorates with high COVID-19 cases including Muscat where As-Seeb city is located. The data clearly shows that Muscat has the highest cases representing almost 50% of the total national COVID-19 cases compared to other governorates.

Table 1  
COVID-19 cases for top-six governorates in Oman, June 2020

Location	Confirm cases	Recovery	Death
Muscat (including As-Seeb)	43981	41694	288
North Batinah	15616	14293	184
South Batinah	10170	9687	111
Al Dakhliyah	5880	5283	51
Dhofar	3760	3221	39
Al Wusta	1739	1664	4
National (Oman) Total	89746	83771	780
Sources: (Ministry of Health 2020; WHO 2020)			

## 2.2.2 Aircraft Data

Aircraft (both take-off and landing) traffic of MCT was acquired from Oman Public Authority for Civil Aviation before and during the COVID-19 pandemic period (PACA 2020). Aircraft traffic data were compared for March-July of the year 2018 and 2019 with March-July 2020 (during the COVI-19 pandemic period) to assess the level of reductions in aircrafts traffic at MCT (Fig. 2). Compared to the previous years (2018–2019), it could be observed that there have been more than 80% reductions in the number of aircraft traffic representing an average of ~ 42,000 flights in MCT due to the COVID-19 pandemic. The reported 9,541 flights were mainly due to evacuation activities, domestic movements, and medical-related travels (PACA 2020).

## 2.3 Noise Impact Assessment

### 2.3.1 Field Measurements

Noise data was acquired through field measurements during the COVID-19 pandemic period for two (2) days starting 19th to 20th June 2020 using a sound level meter (SLM) (BandK Investigator™, Model 2260, Denmark). SLM used in this study is rated as a Type 1 instrument by both the International Electrotechnical Commission (IEC) and American Standard Institute (ANSI) as an outdoor sound pressure meter with a maximum operating frequency of 20kHz (Brüel & Kjær 2020). During the measurements, the SLM was installed at a height of 9.4 m similar to that of most residential story buildings found in the MCT area. A 24-Hour continuous sound pressure level, A-weighted (LAeq dB(A)) noise levels were recorded at seven (7) selected points (M01-M07) randomly located at various residential areas in As-Seeb within a distance of 1.9–4.2 km from the MCT Runway (08L) as shown in **Fig. 1**. These distances were selected as the most suitable areas of noise measurements as the majority of residential and commercial buildings which are found within these ranges, and thus may be highly exposed to aircraft noise levels.

## **2.3.2 Public Survey**

### **2.3.2.1 Study population and Survey Procedure**

A cross-sectional study was conducted by selecting a sample population from adults who are current residents of As-Seeb during the COVID pandemic period, living in closer proximity to the MCT neighborhood and deemed as being exposed to aircraft noise levels. Based on the likelihood of about 25% prevalence level of complaint of aircraft-related annoyance and sleep disorders, the sample size of the exposed population was estimated at 95% confidence intervals (CI) (Paiva et al. 2019; World Health 2011). Online survey through questionnaires were conducted on 26th – 29th June 2020 to assess the impact of aircraft noise levels among the population amid COVID-19 pandemic. As the researchers observed COVID-19 social distancing protocols during the study, the survey questionnaire was administered among Sultan Qaboos University (SQU) staff/students who are living in the study area using their emails rather than field survey study. Prior consent of the participants where sought by indicating "accept" OR "decline" in the emails. The location of the respondents through the google navigation tool was confirmed once they indicated that they dwell in the study area on the questionnaire. The respondents were informed about the objective of the study and the researcher's credibility was assured since the respondents are already affiliated with the SQU community.

### **2.3.2.2 Questionnaire**

The perception of aircraft noise levels, its annoyance, and health effects were assessed using a 5-point verbal scale similar to International Commission on Biological Effects on Noise (ICBEN) scale (Fields et al. 2001) with metrics "not at all", "low", "moderate", "high" and "very high". Also, health impact related questions were asked by open-ended verbal marks such as "No", "Yes" and "Don't know". The study further obtained some basic socio-demographic (i.e.gender and age) data of the participants as well as questions on general sources of noise, and duration of annoyance. The questionnaire was designed in both English and Arabic languages since these are the commonly used languages in Oman (see **the supplementary material**).

## **2.3.3 Data analysis**

All the measured sound pressure levels across the 7-points were expressed as daily (24-hour) noise levels, LAeq dB(A) using Excel Software Program version 2016. Descriptive analysis was performed on socio-demographic profile, annoyance, health impacts, traffic noise source related responses. Chi-Square test using SPSS statistical program, version 23 was adopted to determine the association between aircraft noise levels and level of annoyance, duration of annoyance, perceived adverse health effects, and traffic noise sources. All Chi-Square analyses were conducted at 95% CI by adopting statistical significance at an alpha level of 0.05.

### 3. Results

#### 3.1 Noise Exposure Levels

24-Hour sound pressure levels for LA<sub>eq</sub> and L<sub>max</sub> expressed as dB(A) during the COVID-19 pandemic period (June 2020) are shown in Tables 2 and 3, respectively. During the pandemic, average noise levels (LA<sub>eq</sub>) within the neighborhood of As-Seeb near MCT was observed to be 37.5–40.6 dB(A), with most of the measured locations having similar median noise levels of about 40 dB(A) (Table 2). The minimum sound pressure levels for all the seven (7) measured points were very consistent, and all falling within a range of 30–35 dB(A). Similarly, the daily average L<sub>max</sub> values were found ranging from 46.1–51.9 dB(A) within the same locations with maximum and minimum values observed within 37–43 and 44–60 dB(A), respectively (Table 3). Thus, during the COVID-19 pandemic period, the daily average noise pollution levels in terms of LA<sub>eq</sub> were found to be more than 10 dB(A) lower when compared to WHO's critical limits of 55 dB(A) for community noise exposures. In addition, all measured aircraft noise levels (LA<sub>eq</sub>) (Table 2) were below 45 dB(A), a more stringent aircraft noise standards recommended by Guidelines Development Group (GDG) (WHO 2018). These results clearly showed that the COVID-19 pandemic has caused a drastic decline in aircraft noise levels in the study area.

Table 2

Daily measured aircraft equivalent sound pressure levels LA<sub>eq</sub> expressed as dB(A) amid COVID-19 pandemic near MCT, Muscat, June 2020

Measured Points	Average,dB(A)	Median, dB(A)	Maximum,dB(A)	Minimum, dB(A)
M01	37.5	38.0	44.0	32.0
M02	39.4	40.0	44.0	33.0
M03	40.6	41.0	46.0	34.0
M04	40.7	41.5	49.0	30.0
M05	39.2	39.5	47.0	32.0
M06	40.1	40.0	45.0	35.0
M07	40.6	40.0	49.0	32.0

Table 3  
Daily measured aircraft maximum sound pressure levels  $L_{max}$  expressed as dB(A) amid COVID-19 pandemic near MCT, Muscat, June 2020

Measured Points	Average,dB(A)	Median, dB(A)	Maximum,dB(A)	Minimum, dB(A)
M01	47.5	46.5	60.0	38.0
M02	46.7	45.5	58.0	37.0
M03	49.4	48.0	60.0	40.0
M04	51.9	54.0	60.0	41.0
M05	51.9	53.0	59.0	43.0
M06	48.0	47.5	58.0	38.0
M07	46.1	47.5	54.0	37.0

Visual representation of hourly (8:00–19:00) sound pressure levels of the 7 selected points (M01-M07) near MCT during the COVID-19 pandemic in terms of LAeq and Lmax are shown in Fig. 2. A slight increase in hourly noise levels was observed in the majority of the points (e.g. M01-M06) during the morning (7:00–16:00), then later decline after 19 : 00 and maintained to constant levels until 4:00. All the measured points experienced an increase in the noise levels again after 5:00. These similar patterns of hourly noise levels across all the points clearly show that the MCT area experienced consistent aircraft traffic levels due to the COVID-19 pandemic. This also implies that the noise levels near MCT were not influenced significantly by other sources such as road traffic, industrial, and neighborhood activities (Fig. 3).

Table 4 shows the differences in observed sound pressure levels between the historical (April-May,2019) and the current (June 2020) COVID-19 pandemic timeframes. It can be found that there was a significant reduction in average aircraft noise ( $LA_{eq}$ ) levels by more than 32%, representing about 18 dB(A) in the same residential area (As-Seeb). A similar pattern was observed for  $L_{max}$  noise values, where average pre-COVID-19 aircraft noise values of 76.81 dB(A) (Al-Harthy et al. 2020) was found to be higher compared to the levels during the COVID-19 period of 49.78 dB(A). In overall, the decline of the measured  $L_{max}$  noise by 35% or a value of 27 dB(A) when compared to the historic aircraft noise levels was very similar to that of  $LA_{eq}$  values (Table 4). These recorded low aircraft noise levels near the residential areas of MCT confirm a huge reduction in aircraft traffic volumes during the COVID-19 pandemic (March-July 2020) period compared to the previous historic years (March-July 2018–2019) as illustrated in Fig. 2.

Table 4

Aircraft noise levels of current and historical durations measured near MCT, Muscat of Oman COVID-19 pandemic for average daily  $L_{Aeq}$  and  $L_{max}$  in dB(A)

Measured Noise	Current (June 2020) mean (SD)	Historical (April-May 2019) mean (SD)	Differences (%change )
$L_{Aeq}$	39.72(1.15)	58.55(3.81)	-18.83 (-32.16%)
$L_{max}$	49.78(2.36)	76.81(5.42)	-27.03(-35.19%)

Note: The historical noise levels were acquired from Al-Harthy et al. (2020). The historical (measured in April-May, 2019) and the current noise (measured in June 2020) levels consisted of 15 and 7 measured points, respectively. SD: Standard Deviation

## 3.2 Noise Impact Assessment Results

In overall, 187 participants enrolled in the online survey study during the COVID-19 pandemic period. This represents a response rate of 65% when compared to the WHO's assumed sample size of ~ 290 for the prevalence of reports associated with sleep disorders and annoyances from traffic noise exposures (Amoatey et al. 2020; Paiva et al. 2019). The majority of the respondents (51.3%) were within 25–50 years of age with about 29% having more than 50 years. About 109 of the study participants were female, representing 58.3%, this was slightly higher compared to male (41.7) counterparts (Table 5).

For general community noise levels, very few people representing about 2%, 1%, 4%, and 6% viewed that noise levels as very high, and are normally from industrial, construction, neighborhood, and road traffic sources, respectively. Most of the participants (61.5%) found industrial activities have not been a source of noise at all, with nearly 30% having the same opinion for the other community noise sources. Aircraft related noise exposure levels during the COVID-19 pandemic was considered by 38.5% of the respondents as low with few people feeling it as very high. Interestingly, about a quarter of the study participants (24.1%) believed that aircraft traffic activities during the COVID-19 pandemic do not produce noise at all (Table 5).

Table 5

Sociodemographic features and perception of noise sources during COVID-19 pandemic era reported by residents living closer proximity to MCT in Muscat, Oman

Variable	N	% of Respondents	Total	p-value*
<b>Respondents</b>				
<b>Gender</b>			187	0.023
Male	78	41.7		
Female	109	58.3		
<b>Age (years)</b>			187	< 0.001
< 25	37	19.8		
25–50	96	51.3		
> 50	55	28.9		
<b>Sources of Noise at home</b>				
Industrial noise			187	< 0.001
Not at all	115	61.5		
Low	55	29.4		
Moderate	9	4.8		
High	4	2.1		
Very high	4	2.1		
Construction noise			187	< 0.001
Not at all	68	36.4		
Low	65	34.8		
Moderate	41	21.9		
High	11	5.9		
Very high	02	1.1		
Neighborhood			187	< 0.001
Not at all	73	39		
Low	78	41.7		
Moderate	22	11.8		
High	07	3.7		

Variable	N	% of Respondents	Total	p-value*
Respondents				
Very high	07	3.7		
Road traffic			187	< 0.001
Not at all	70	37.4		
Low	57	30.5		
Moderate	33	17.6		
High	15	8.0		
Very high	12	6.4		
Aircraft			187	< 0.001
Not at all	45	24.1		
Low	72	38.5		
Moderate	32	17.1		
High	23	12.3		
Very high	15	8.0		

Regarding aircraft noise annoyance levels, Table 6 illustrates reported annoyance levels and related health impacts during the COVID-19 pandemic period among the residents who live near MCT. During this period, the majority (58.8%) of the respondents did not feel that the level of noise produced by aircraft causes annoyance. The magnitude of the annoyance was reported to be slightly by the greater proportion (33.7%) of the residents with about 28.3% people considering it as not causing annoyance at all. However, very few (15.5%) respondents deemed the current aircraft noise levels amid the COVID-19 pandemic as causing extremely annoyance. It was also found that the majority of the respondents did not complain of any annoyance during the morning (45.5%), afternoon (39.6%), and evening (31%). Only about 12% of the participants considered the aircraft noise exposures as high especially during the afternoon and evening time of the day. However, less than 4% of residents reported a very high degree of annoyance during this COVID-19 pandemic period. With regard to potential health impact, more than half of the participants (53.4%) stated that they did not experience any adverse health effects due to aircraft noise levels during the current COVID-19 pandemic period. Very few respondents of nearly 18% did report experiencing general health problems while 29% did not know of any health effects caused by aircraft noise levels during the COVID-19 pandemic period (Table 6). The study also found an association between As-Seeb dwellers who have been exposed to aircraft noise levels during the COVID-19 pandemic period and feeling of annoyance ( $p < 0.016$ ); the degree of noise annoyance ( $p < 0.003$ ) and time (morning, afternoon, evening) of the annoyance during the day. It was further found that there was a

significant association between reporting of health effects by the respondents and aircraft noise exposure levels amid the COVID-19 pandemic (Table 6).

Table 6

Aircraft noise annoyance levels and related health impacts during COVID-19 pandemic era reported by residents living closer proximity to MCT in Muscat, Oman

Variable	N	% of Respondents	Total	p-value*
	Respondents			
<b>Aircraft annoyance</b>			187	0.016
Yes	77	41.2		
No	110	58.8		
<b>Degree of aircraft annoyance</b>			187	0.003
Not at all	53	28.3		
Slightly	63	33.7		
Moderate	42	22.5		
Extremely	29	15.5		
<b>Duration of annoyance</b>				
Morning			187	< 0.001
Not at all	85	45.5		
Low	51	27.3		
Moderate	35	18.7		
High	10	5.3		
Very high	06	3.2		
Afternoon			187	< 0.001
Not at all	74	39.6		
Low	55	29.4		
Moderate	30	16.0		
High	23	12.3		
Very high	05	2.7		
Evening			187	< 0.001
Not at all	58	31		
Low	57	30.5		

\*Significant at p < 0.05 at 95% CI

Variable	N	% of Respondents	Total	p-value*
	Respondents			
Moderate	41	21.9		
High	24	12.8		
Very high	07	3.7		
<b>Health effects from aircraft noise</b>			187	< 0.001
Yes	33	17.6		
No	100	53.4		
Don't know	54	29.0		

\*Significant at p < 0.05 at 95% CI

## 4. Discussion Of Results

The COVID-19 pandemic has caused serious restrictions in air travels leading to a substantial reduction of about 2.8-3.0 million airline passenger traffic populations and with a revenue loss of US\$ 400 billion as a result of the closure of several international airports across the globe (Iacus et al. 2020b; ICAO 2020). This unprecedented decline in aircraft activities has created positive effects on aircraft noise pollution reductions among populations dwelling closer to airport areas. This current study centered on assessing aircraft noise exposure levels, annoyance, and potential health effects related to aircraft traffic among residents living in close proximity to MCT.

The study observed a significant reduction in noise levels by 32% and 35% for  $LA_{eq}$  and  $L_{max}$ , during the COVID-19 pandemic compared to the previous year of 58.5 and 76.8 dBA, respectively. This reduction in sound pressure levels is due to a decline in both international and domestic airline traffic levels in Oman during the COVID-19 pandemic. These were also attributed to reduction in commercial (e.g. in hospitality industries) businesses, mobility of people, and road traffic activities related to the MCT operation, thereby leading to an overall decline in overall community noise levels. The response from the social survey conducted revealed that the majority of the respondents do acknowledge that low noise levels during the COVID-19 were not only attributed to reduced aircraft traffic activities but also the due decline in neighborhood, road traffic, and industrial activities as well. This was mainly due to the lockdowns and social distancing measures introduced by the government of Oman with the overall aim of reducing the spread of COVID-19 infections (Khamis et al. 2020).

Noise annoyance, irritation, and sleep disturbances were recognized as the most common health effects of aircraft noise exposures by several studies that were conducted during the pre-COVID19 pandemic (Baudin et al. 2020; Nassur et al. 2019; Nassur et al. 2018). This study observed very low complaints of noise annoyance levels during all three different (morning, afternoon, and evening) durations of the day

among the respondents. This was found to be consistent with low aircraft noise levels measured during the same COVID-19 pandemic period. The previous study conducted by Al Harthy (2007) before the COVID-19 pandemic reported that the majority of the residents complaining of a high level of annoyance compared to this current study. With regard to health impacts, most of the residents are of the opinion that there are low risks of developing health problems during the COVID-19 pandemic owing to low aircraft noise levels within the neighborhood. Thus, there is a high possibility that if the COVID-19 pandemic continues, there will be an improvement in cardiovascular health among the exposed population as the health risk factors such as hypertension, high blood pressure will be reduced due to low aircraft noise levels (Eriksson et al. 2007). It is also feasible that future noise mitigation (e.g. noise barriers, redesigning of airports, etc.) programs could yield results by reducing aircraft noise exposure levels, annoyance, and health problems if those noise levels is to decline to the levels observed during the COVID-19 pandemic period. This study has several strengths. Firstly, the real-time aircraft noise levels reported in this study during the COVID-19 pandemic could be utilized as background noise levels since such datasets are limited in neighborhood populations that have been frequently exposed to high aircraft traffic levels. Also, the annoyance levels reported in this study could be used as a baseline indicator when embarking on future noise abatement programs especially during the post-COVID-19 pandemic period. The major limitation associated with this study is due to lack of high resolution measured noise and health impact assessment data, as the questionnaire used were biased towards the assessment of annoyance levels with limited knowledge on potential health effects such as sleep disturbance and cardiovascular diseases among the respondents. Also, the study could not enroll a large number of participants which are crucial to better understand the effect of the COVID-19 pandemic on aircraft noise annoyance and health impacts.

## 5. Conclusions And Recommendations

This study aimed at assessing aircraft noise exposure levels, annoyance, and potential health effects among residents living in close proximity to MCT during the COVID-19 pandemic period. The outcome of the study revealed a significant reduction in aircraft noise ( $LA_{eq}$  and  $L_{max}$ ) levels posed by low aircraft traffic activities during the COVID-19 pandemic compared to the pre-pandemic period. The reduced aircraft noise levels have led to an improvement in acoustic discomfort where the majority of the study participants considered the aircraft noise annoyance levels as low with the potential of not causing adverse health effects. It was also found that during the day, the vast majority of the interviewees did not complain of any annoyance during the morning (45.5%), afternoon (39.6%), and evening (31%) with < 4% of residents having reported very high degree annoyance of during the amid COVID-19 pandemic period. Only about 17% did complain of experiencing general health problems while 29% did not know of any potential health effects that could be attributed to aircraft noise exposures. It is expected this study could be used as a baseline indicator for future noise abatement programs after the COVID-19 pandemic period to help determine at which aircraft noise exposure level is likely to cause low annoyance and health impacts. Also, this study could be used as a prototype in other populations living in closer proximity to airport areas with reduced aircraft traffic activities due to the COVID-19 pandemic. These findings support

the need to further mitigate the current aircraft noise threshold limits in order to improve the acoustic conditions of the exposed populations and reduce noise related annoyance and improve cardiovascular health problems.

## Declarations

### Declaration of Competing Conflict of Interest

Authors declare no potential competing conflict of interest in terms of finance or personal relationship that could influence this study.

### Ethics approval and consent to participate

The respondents who participated the online survey first received an option of "accept" or "decline" filling of the questionnaires . Thus, consent have been sought for those who accepted to participate in this study.

### Consent for publication

Not applicable

### Availability of data and materials

Not applicable

### Funding

None

### Declaration of Conflict of Interest

Authors wish to declare no competing conflict of interest.

### Authorship Contribution

**Patrick Amoatey** was involved with conceptualization, methodology, data analysis, and writing of the first draft of the manuscript. **Issa Al-Harthy** assisted in conceptualization, methodology, data analysis, provision of resources, review, and editing of the paper. **Khalifa Al-Jabri** provided funding, assisted in conceptualization, data analysis, provision of resources. **Abdullah Al-Mamun** was involved in conceptualization, methodology, data analysis, review, and editing of the manuscript. **Mahad Said Baawain** assisted in conceptualization, methodology, data analysis, provision of resources. **Ahmed Al-Mayahi** was involved in methodology, data analysis, review, and editing of the paper.

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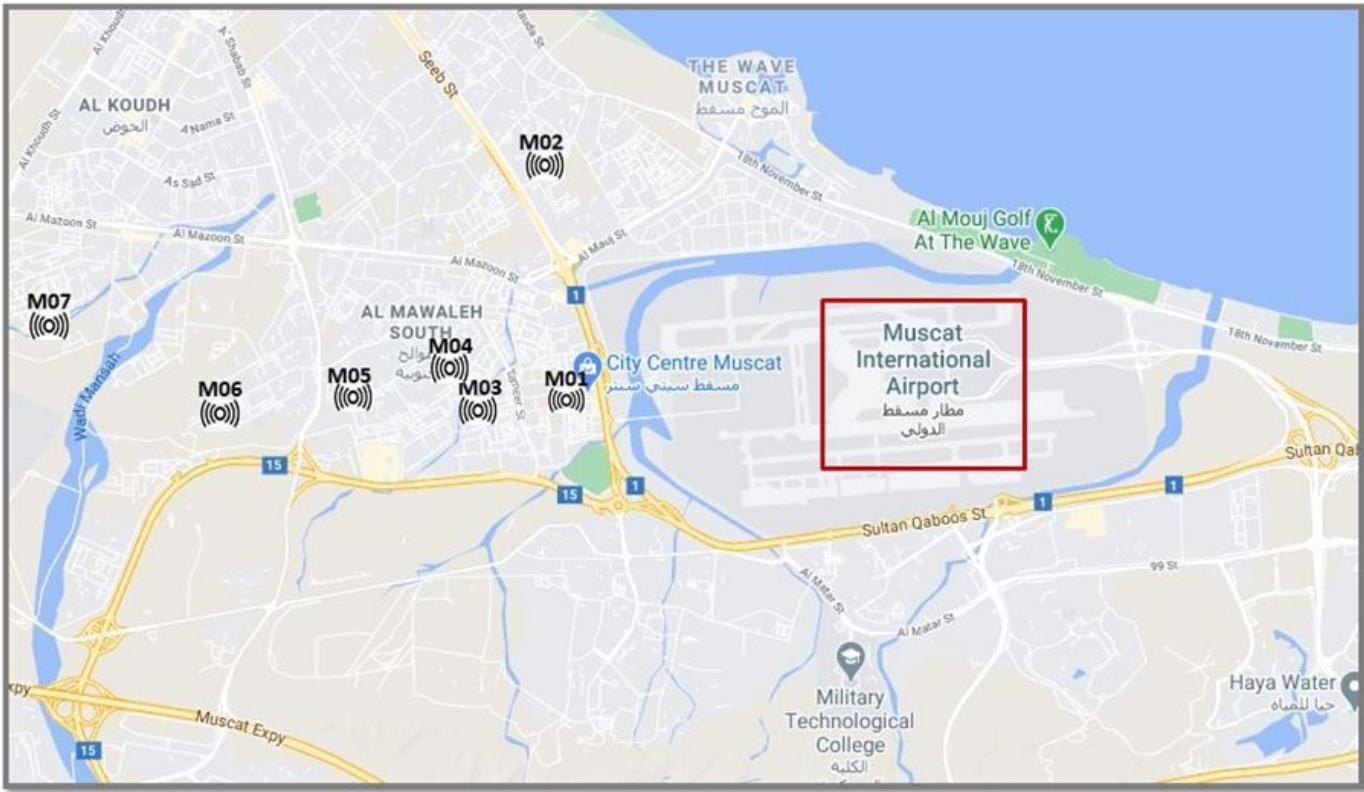
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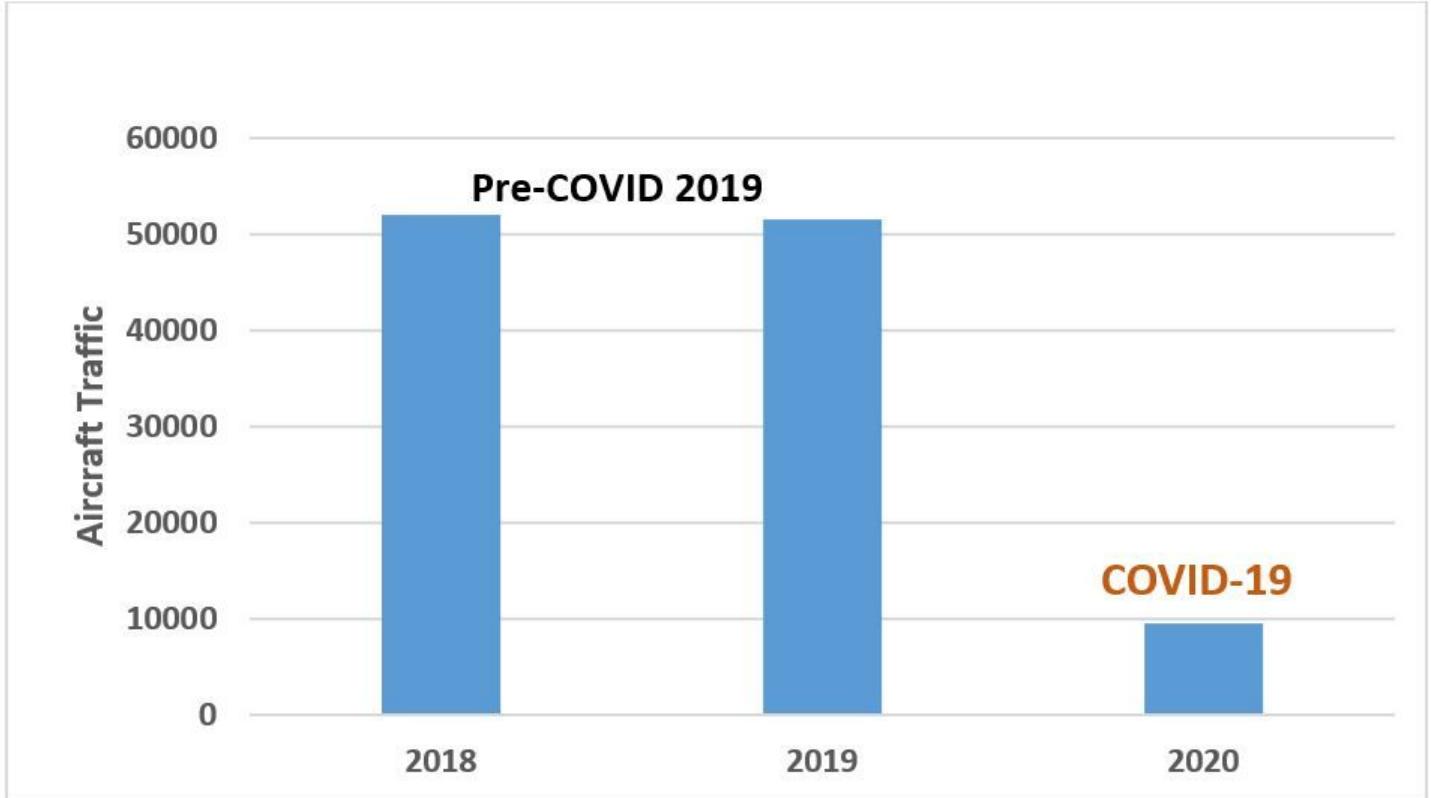
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## Figures



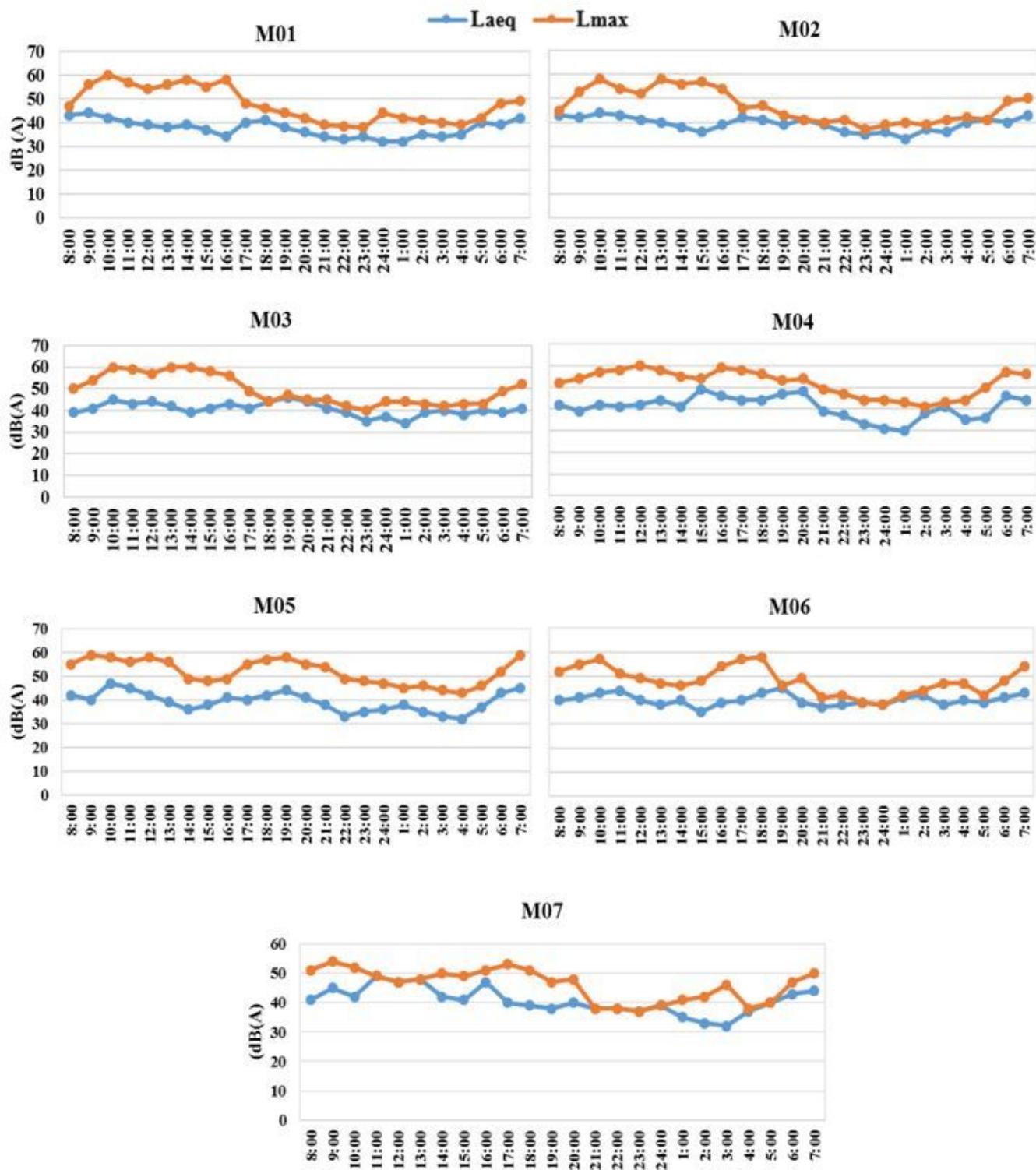
**Figure 1**

A map showing the location of the study area and noise measurement points Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.



**Figure 2**

Aircraft traffic at MCT during COVID-19 pandemic (March-July 2020) compared to the same months of the previous years (2018 and 2019), Source: PACA (2020)



**Figure 3**

Hourly noise levels (L<sub>Aeq</sub>, L<sub>max</sub>) near MCT, Muscat amid COVID-19 pandemic

## Supplementary Files

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- SupplementaryData.docx