The impact of air quality on tourism: a systematic literature review

Celeste Eusébio, Maria João Carneiro, Mara Madaleno, Margarita Robaina, Vítor Rodrigues, Michael Russo, Hélder Relvas, Carla Gama, Myriam Lopes, Vania Seixas, Carlos Borrego and Alexandra Monteiro

Abstract

Purpose – *Tourism may have important positive and negative economic, socio-cultural and environmental impacts. However, cultural and natural resources are also the base to the development of competitive destinations and changes in these resources can have an important impact on tourism development. Despite the considerable literature regarding the impacts of tourism, a limited number of studies examine the impact of the environment on tourism, specifically the impact of air quality (AQ). Therefore, this paper aims to review what is known about the impact of AQ on tourism demand, analysing the different methods and approaches used, as well as the results obtained.*

Design/methodology/approach – *A systematic literature review method was used to examine the state of the art in this topic and identify research gaps and new research directions. Only 26 papers were identified that examine the impact of AQ on tourism demand.*

Findings – *The majority of the studies were carried out in China and investigate the impact of AQ on tourism from the perspective of tourism demand. Both global (tourism demand) and individual (tourist perceptions) approaches have been used to investigate the impact of AQ on tourism.*

Originality/value – *This is the first systematic literature review on the impact of outdoor AQ on tourism demand. Moreover, this paper analyses the methods and approaches that have been used in the literature to examine the impact of outdoor AQ on tourism demand. The paper ends with a discussion on the identified research gaps concerning the influence of AQ on tourism development.*

Keywords *Tourism, Air quality, Impact, Air pollution, Systematic literature review*

Paper type *Research paper*

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1. Introduction

In the present era, one of the major motivations for travelling is to avoid the usual environment and seek a site with a pleasant location for releasing psychological stress and pressure (Ritchie and Crouch, 2003). Therefore, environmental quality must be taken into account as an important factor in the decision-making process of potential tourists, as it can have a significant effect on the competitiveness of tourism destinations (Zhang *et al.*, 2015; Becken *et al.*, 2017). However, the environment in some large tourism destination countries such as Egypt, China and India, is deteriorating with the progressive urbanization and industrialization. Beyond the "traditional" environmental problems such as garbage disposal and water pollution, the problem of haze pollution has risen in recent years, and air quality (AQ) has become a universal concern (Chen *et al.*, 2017), now being incorporated into the wider category of environmental quality.

Ambient AQ should attract more academic attention than thermal comfort and the aesthetic dimension of the physical environment, as AQ is closely related to health risks (Costa *et al.*, 2014). However, the existing literature places relatively low attention on the effects of AQ on tourism demand and the competitiveness of tourism destinations. Overall, the impacts of

environmental and climate change issues on tourism have previously been discussed in several studies but few of them have focussed directly on the impacts of air pollution on the competitiveness of a tourism destination (Saenz-de-Miera and Rosselló, 2013; Rossello-Nadal, 2014; Sajjad *et al.*, 2014). AQ also pertains to physical comfort, which is crucial to tourist experiences and has become a severe concern for human health. Medical evidence suggests that short and long-term exposures to ambient air pollution can engender a wide variety of acute and chronic health problems (Seaton *et al.*, 1995; WHO, 2017). Moreover, AQ also affects aesthetic enjoyment, with people's perception of reduced visibility, which is affected by the presence of particles and haze, which is being increasingly researched (Rizzi *et al.*, 2014).

The objective of this paper is to review what is known and has been published, about the impact of outdoor AQ on tourism demand, using a systematic literature review method. To date, there is no literature review study on this topic. It is of note that the impact of tourism on AQ was also not addressed. This literature review aims to identify the geographical context, research methodologies used, researched subjects of the papers and the findings on the impact of AQ on tourism. This approach was adopted to provide contributions to guide future research, regarding which models should be used and what kind of data needs to be collected.

The paper is organized in various sections. In Section 2, the methodology used to select and analyse the papers is presented. In Section 3, the findings are reported, specifically the distribution of papers over time, among journals, subject areas, authorship and citations, the geographical contexts of the studies and the research methods used (data collection and data analysis methods), as well as the key results found. Finally, in Section 4, the main conclusions are summarized, research gaps are identified and some research questions are proposed to overcome these gaps.

2. Methodology

Several types of methodologies have been used in previous articles to conduct a literature review (e.g. systematic literature review, structured literature review, bibliometric analysis and systematic literature network analysis) (Centobelli and Ndou, 2019; Comerio and Strozzi, 2019). The differences among these methodologies are mainly related to the research protocol used. In this paper, a systematic literature review is applied and the research protocol used encompasses two stages. First, a protocol was defined and put into practice to select the articles that will be analysed. Second, a content analysis of the articles selected was undertaken.

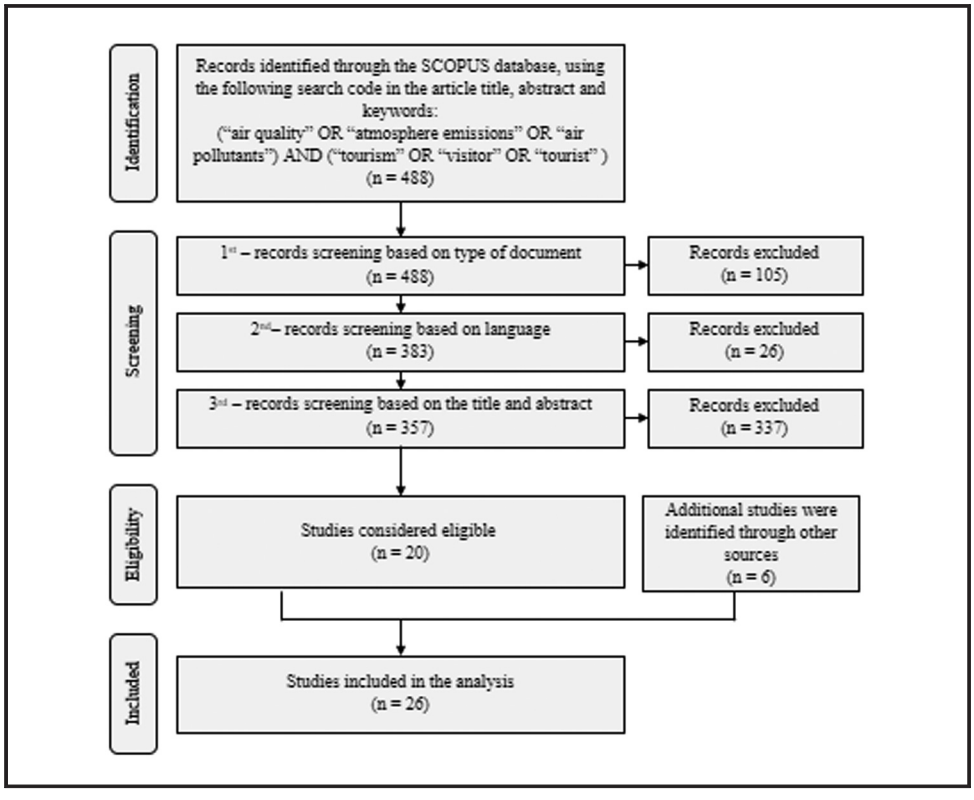
2.1 Articles selection

The protocol used to select the papers is reported in Figure 1.

As presented in Figure 1, the identification of the studies was carried out through a search on the Scopus database during January 2019, using the following search code – ("AQ" or "atmospheric emissions" or "air pollutants") and ("tourism" or "visitor" or "tourist") – in the article title, abstract and keywords without any restriction of time or subject. This database has been used in several previous studies (Centobelli and Ndou, 2019; Comerio and Strozzi, 2019; Dann *et al.*, 2019) and is one of the largest databases of peer-reviewed literature (scientific journals, books and conference proceedings). A total of 488 records were obtained. Further, to include both scientific literature and "grey" literature, articles, reviews, articles in press and conference proceedings were selected. As a consequence of this first screening, the sample of records reduced to 383. Further, only documents written in English were selected. Papers written in other languages were excluded, given the complexities associated with translation. Based on this screening, 26 records were excluded.

Manual screening of the abstract titles and the abstracts of the 357 records was carried out by two authors (one specialized in AQ and the other in tourism) to verify if each paper was

Figure 1 PRISMA flow diagram of the article selection process



relevant to be included in this research. When the title and the abstract were not conclusive, the whole article was analysed. Concerning the inclusion criteria, it was decided to include both conceptual and empirical studies (qualitative and quantitative), where the influence of outdoor AQ on tourism demand of a tourism destination was analysed. Therefore, papers regarding the environmental impact of tourism on AQ and studies concerning indoor AQ of tourism attractions and facilities were excluded from this systematic literature review. A great number of documents only mention the topics of AQ and tourism in a superficial way, without an analysis of the impact of outdoor AQ on tourism demand. Consequently, only 20 papers were selected. To increase the sample of papers selected, two complementary searches were carried out on the Google Scholar database and Online Knowledge Library (b-on). From these analyses, only one additional paper was added. Further, the references of the 21 papers identified were analysed and 5 more papers were included in the sample. Consequently, a total of 26 papers were selected to be analysed in the second stage of this systematic literature review. This reduced number of papers clearly shows that this topic has been almost neglected in the literature, despite the great increase that the tourism industry has registered in the past few years and the increase in well-being and health concerns.

2.2 Articles analysis

The articles selected in the previous stage were analysed using two steps. First, a descriptive analysis of the following aspects was carried out:

- The distribution over time;
- Distribution by journal, scientific area and authorship; and
- The distribution by the geographical context where the study was conducted.

As both empirical and theoretical studies were found, in a second stage, a content analysis of the empirical papers was developed to identify as follows:

- The research methods (data collection and data analysis methods);
- The dimensions of AQ and tourism demand investigated; and
- The results obtained concerning the impact of outdoor AQ on the dimensions of tourism demand analysed.

This content analysis was complemented with an investigation of word frequencies (in title, abstract and keywords), using the Nvivo software, to identify, through word clouds, the terms most frequently used in this research field.

3. Findings

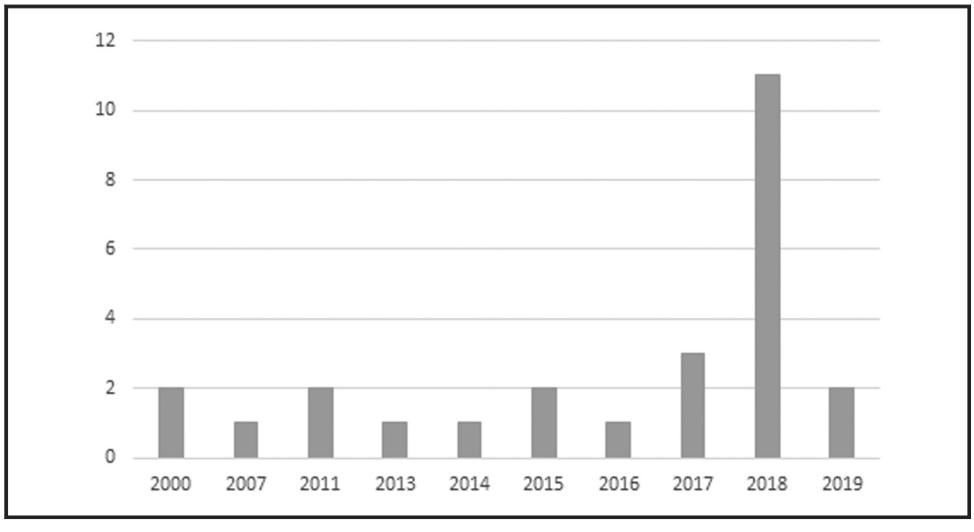
3.1 Distribution of the papers over time

A total of 26 papers were analysed. There seems to be a growing interest on the impact of outdoor AQ on tourism demand among researchers, as most of these papers were published in the past decade (88 per cent), mainly in 2017 and 2018 (12 and 42 per cent of the total set of papers were published in these years, respectively) (Figure 2).

3.2 Journals, authorship and citations

There is a great variety among the authors of these papers. Almost all (98 per cent) wrote one paper and only Rob Law is the author of two. The papers are published in journals and conference proceedings of several areas, which reveals the relevance of this topic to different fields. However, there is a higher prevalence of papers in journals or proceedings from the field of "tourism, leisure and hospitality management" (38 per cent), with a notable contribution of "environmental science" (19 per cent), also having some papers published in journals or proceedings in the areas of "geography, planning and development" (8 per cent) and "health" or "medicine" (8 per cent) (Table I). It is important to notice that journals or proceedings can be related to more than one field, for example, environment and health. Papers have, on average, 7.2 citations in Scopus and 11.0 citations in Google Scholar. However, there is a high variation regarding citations, with many of the most recent papers

Figure 2 Number of papers published by year of publication



(representing 19 per cent of the total) not yet having any citations in Scopus or Google Scholar, while 23 per cent have more than 20 citations in Scopus or in Google Scholar (Table I).

3.3 Geographical context

In terms of geographical areas, Figure 3 reveals that the spatial distribution of the published work addressing the impact of AQ on tourism is mainly focussed over the China and Southeast Asia regions.

China emerges as the country where most studies were conducted (about 42 per cent of the total), mainly in its capital (Beijing) with five specific studies focussed on this city (and not included in the six studies for China as a country shown in Figure 2). When other Asian countries are considered, the number of studies carried out in this region represents 58 per cent of the total studies analysed. Moreover, 16 per cent of the published studies were undertaken in the USA. A limited number of studies were conducted in European countries.

3.4 Most frequently used terms

The word clouds were generated through the qualitative analysis software NVivo 12, which allowed us to develop a word frequency query. To do so, this task separately analysed the word frequency in specific items of the mentioned papers, namely, the title, keywords and abstract. By default, the software automatically excludes the so-called "stop words", which refer to conjunctions and/or prepositions and similar, which helped to substantially reduce the number of meaningless words. In each case, the words with a frequency equal to "1" were excluded, mainly because they may not be meaningful to the study objectives. Additionally, the following expressions, matching with the search terms used in the initial protocol, were also excluded: "AQ", "atmospheric emissions", "air pollutants", "tourism", "visitor" and "tourist". To obtain more accurate results, the words were grouped according to the option "stemmed words", which groups similar words such as "significant" and "significantly".

Originally, the analysis generated 930 words in the case of the abstracts, 142 for the titles and 118 for keywords. By applying the above-mentioned filter, the final result was a total of 432, 31 and 38 words, respectively. Based on each list of frequencies, the software created the following word clouds (Figure 4). Focussing on the top five of the most significant words, and as observed in Figure 4, only the expressions "pollution" and "environmental" are common in the analysed lists. The words "impact", "China" and "perceptions" also appear with high frequency in, at least, two of the three lists of frequencies and "parks" or "haze", reflecting the common topics between the several considered studies.

3.5 Research methods

Most papers selected for this systematic review include empirical studies, only one is a literature review (Zajchowski *et al.*, 2018). The literature review carried out by Zajchowski *et al.* (2018) differs from the one in the present paper, as it only focusses on the social and psychological effects of degraded AQ in and around parks and protected areas, and only analyses papers published in journals. In contrast, the analysis carried out in the present paper focussed, as already mentioned, on destinations, excluding specific attractions, but encompassed a wider range of documents, including papers published in conference proceedings. Only three papers – Hill *et al.* (2000), Keiser *et al.* (2018) and Zhang *et al.* (2015) – are cited in the two literature reviews.

In this section, the methods used in the papers that include an empirical study to collect and analyse the data are described. It was considered useful to include a summary of the methodologies adopted to examine the influence of outdoor AQ on tourism. This would be

Table I Information on the publication, authorship and citations (continues)

Authors (year of publication)	*Title of the paper*	*Journal or proceedings*	*Domain of the journal or proceedings*	*Citations in SCOPUS*	*Citations in Google Scholar*
Anaman and Looi (2000)	Economic impact of haze-related air pollution on the tourism industry in Brunei Darussalam	*Economic Analysis and Policy*	Economics, econometrics and finance: economics and econometrics	14	31
Hill *et al.* (2000)	Visitor Perceptions and Valuation of Visibility in the Great Gulf Wilderness, New Hampshire	*USDA Forest Service Proceedings*	a)	a)	8
Law and Cheung (2009)	Air Quality in Hong Kong: A Study of the Perception of International Visitors	*Journal of Sustainable Tourism*	Business, management and accounting: tourism, leisure and hospitality management	13	21
Bohm and Pfister (2011)	Tourism in the Face of Environmental Risks: Sunbathing under the Ozone Hole, and Strolling through Polluted Air	*Scandinavian Journal of Hospitality and Tourism*	Business, management and accounting: tourism, leisure and hospitality management	1	4
Hipp and Ogunseitan (2011)	Effect of environmental conditions on perceived psychological restorativeness of coastal parks	*Journal of Environmental Psychology*	Psychology: applied Psychology	30	53
Poudyal *et al.* (2013)	Estimating the impact of impaired visibility on the demand for visits to national parks	*Tourism Economics*	Business, management and accounting: tourism, leisure and hospitality management	13	18
Sajjad *et al.* (2014)	Climate change and air pollution jointly creating nightmare for tourism industry	*Environmental Science and Pollution Research*	Environmental science: pollution	25	39
Nejati *et al.* (2015)	The Influence of Perceived Environmental Impacts of Tourism on the Perceived Importance of Sustainable Tourism	*e-Review of Tourism Research*	Business, management and accounting: tourism, leisure and hospitality management	4	6
Zhang *et al.* (2015)	Tourists' Perception of Haze Pollution and the Potential Impacts on Travel: Reshaping the Features of Tourism Seasonality in Beijing, China	*Sustainability*	Social sciences: geography, planning and development	28	40
Sato *et al.* (2016)	Effect of Short-Term Exposure to High Particulate Levels on Cough Reflex Sensitivity in Healthy Tourists: A Pilot Study	*Open Respiratory Medicine Journal*	Medicine: Pulmonary and Respiratory Medicine	2	4
Becken *et al.* (2017)	Urban air pollution in China: destination image and risk perceptions	*Journal of Sustainable Tourism*	Business, management and accounting: tourism, leisure and hospitality management	11	20
Deng *et al.* (2017)	Evaluating impact of air pollution on China's inbound tourism industry: a spatial econometric approach	*Asia Pacific Journal of Tourism Research*	Business, management and accounting: tourism, leisure and hospitality management	4	6

(*continued*)

Table I

Authors (year of publication)	*Title of the paper*	*Journal or proceedings*	*Domain of the journal or proceedings*	*Citations in SCOPUS*	*Citations in Google Scholar*
Agarwal *et al.* (2018)	Blessing in disguise? Environmental shocks and performance enhancement	*a)*	*a)*	*a)*	*a)*
Jun-Hui (2018)	Research on the Tourists' Type and Behavior based on the Fog and Haze Perception: Taking Xi'an as a Case	*E3S Web of Conferences 53*	Environmental science: general environmental science	0	0
Keiser *et al.* (2018)	Air pollution and visitation at US national parks	*Science Advances*	Multidisciplinary	3	4
Pant *et al.* (2018)	Exposure to air pollutants in Vietnam: Assessing potential risk for tourists	*Journal of Environmental Sciences*	Environmental Science: general environmental science	1	2
Peng and Xiao (2018)	How does smog influence domestic tourism in China? A case study of Beijing	*Asia Pacific Journal of Tourism Research*	Business, management and accounting: tourism, leisure and hospitality management	1	1
Saura *et al.* (2018)	Attitudes Expressed in Online Comments about Environmental Factors in the Tourism Sector: An Exploratory Study	*International Journal of Environmental Research and Public Health*	Environmental science: health, toxicology and mutagenesis	10	4
Wang *et al.* (2018)	Effect of air quality in the place of origin on outbound tourism demand: Disposable income as a moderator	*Tourism Management*	Business, management and accounting: tourism, leisure and hospitality management	3	4
Wu *et al.* (2018)	Chinese behind the wheel: factors affecting their satisfaction with international self-drive holidays	*Journal of Destination Marketing and Management*	Business, management and accounting: marketing	0	0
Zajchowski *et al.* (2018)	Air quality and the visitor experience in parks and protected areas	*Tourism Geographies*	Business, management and accounting: tourism, leisure and hospitality management	2	2
Zhou *et al.* (2018)	Air quality and inbound tourism in China	*Tourism Analysis*	Business, management and accounting: tourism, leisure and hospitality management	1	2
Zhu (2018)	Analysis on the Impact of haze on Beijing Residents' Traveling Intention and Decision-Making	*IOP Conference Series: Materials Science and Engineering*	Engineering: general engineering	0	0
Liu *et al.* (2019)	Tourism Development, Environment and Policies: Differences between Domestic and International Tourists	*Sustainability*	Social sciences: geography, planning and development	0	0
Yan *et al.* (2019)	Exploring the effect of air pollution on social activity in China using geotagged social media check-in data	*Cities*	Social sciences: urban studies	1	0

Note: a) No information is provided in SCOPUS or in Google Scholars

Table II Type of data, collection method and sources

Type of data	*Type of data collection method/ sources*	*Authors/year*
Primary data	Questionnaires	Becken *et al.* (2017), Bohm and Pfister (2011), Hill *et al.* (2000), Hipp and Ogunseitan (2011), Jun-hui (2018), Law and Cheung (2009), Nejati *et al.* (2015), Peng and Xiao (2018), Wu *et al.* (2018), Zhang *et al.* (2015) and Zhu (2018)
	Interviews	Wu *et al.* (2018)
	Experiments	Pant *et al.* (2018) and Sato *et al.* (2016)
Secondary data	Quantitative data provided by national or international sources	Agarwal *et al.* (2018), Anaman and Looi (2000), Chen *et al.* (2017), Deng *et al.* (2017), Hipp and Ogunseitan (2011), Jun-hui (2018), Keiser *et al.* (2018), Liu *et al.* (2019), Pant *et al.* (2018), Poudyal *et al.* (2013), Sajjad *et al.* (2014), Wang *et al.* (2018), Yan *et al.* (2019) and Zhou *et al.* (2018)
	Online reviews	Agarwal *et al.* (2018) and Saura *et al.* (2018)

Table III Methods of data analysis

Type of methods	*Description of the method*	*Authors/year*
Qualitative	Content analysis	Saura *et al.* (2018) and Wu *et al.* (2018)
Quantitative	Descriptive statistics	Agarwal *et al.* (2018), Anaman and Looi (2000), Becken *et al.* (2017), Bohm and Pfister (2011), Hill *et al.* (2000), Hipp and Ogunseitan (2011), Jun-hui (2018), Law and Cheung (2009), Liu *et al.* (2019), Nejati *et al.* (2015), Pant *et al.* (2018), Poudyal *et al.* (2013), Sato *et al.* (2016), Saura *et al.* (2018), Wang *et al.* (2018), Wu *et al.* (2018), Yan *et al.* (2019), Zhang *et al.* (2015), Zhou *et al.* (2018) and Zhu (2018)
	Correlations	Hipp and Ogunseitan (2011), Pant *et al.* (2018), Saura *et al.* (2018) and Zhang *et al.* (2015)
	χ^2 tests	Zhu (2018)
	t-tests	Hipp and Ogunseitan (2011), Law and Cheung (2009), Sato *et al.* (2016) and Saura *et al.* (2018)
	ANOVA; multivariate analysis of variance	Becken *et al.* (2017), Bohm and Pfister (2011), Law and Cheung (2009) and Sato *et al.* (2016)
	Reliability analysis (Cronbach's alpha)	Wu *et al.* (2018)
	Exploratory factor analyses; and confirmatory factor analyses	Becken *et al.* (2017), Peng and Xiao (2018) and Zhu (2018)
	Linear regression analyses	Agarwal *et al.* (2018), Anaman and Looi (2000), Keiser *et al.* (2018), Wang *et al.* (2018) and Wu *et al.* (2018)
	Logit models	Agarwal *et al.* (2018) and Hipp and Ogunseitan (2011)
	Poisson regression	Anaman and Looi (2000)
	Spatial models	Deng *et al.* (2017)
	Structural equation models	Becken *et al.* (2017), Nejati *et al.* (2015) and Peng and Xiao (2018)
	Panel data fixed effects model	Agarwal *et al.* (2018), Liu *et al.* (2019), Wang *et al.* (2018), Yan *et al.* (2019) and Zhou *et al.* (2018)
	Corrected least squares dummy variable model	Zhou *et al.* (2018)
	Markov regime-switching model	Chen *et al.* (2017)
	VAR model	Sajjad *et al.* (2014)
	Contingency models	Hill *et al.* (2000)
	Polynomial distributed lag model	Poudyal *et al.* (2013)

helpful in future research to identify potential methodologies that may be used to assess this influence.

3.5.1 Type of data and data collection methods. In terms of the type of data used, the observed sample of articles reviewed is well distributed between primary and secondary data (Table II). A total of 56 per cent of our sample used primary data. From these,

11 articles use questionnaires to explore the relationship between AQ and tourism. Only one study relies on interviews directed to tourists and two rely on experiments to extract primary data. The data sources used to collect secondary data correspond to diverse sources, which can be divided into quantitative data and online reviews. In total, 14 studies collect data from quantitative national and international sources to explore the AQ-tourism relationship and only two of the reviewed articles consider tourists' online reviews as secondary source data. Moreover, some studies simultaneously use primary and secondary data sources to drive reliable conclusions, merging experiments or questionnaires with secondary data. At least Hipp and Ogunseitan (2011), Jun-hui (2018) and Pant *et al.* (2018) simultaneously use primary and secondary data. To study visitors' perceptions of AQ or to infer about the impact of air pollution on tourism, the joint use of questionnaires and evaluations collected from well-known travelling opinion surveys (such as in TripAdvisor; Saura *et al.*, 2018) can be particularly efficient and practical.

3.5.2 Data analysis methods. Table IV presents a summary of the methodologies used by the authors considered in this literature review regarding the impacts of AQ on tourism. Most of the studies analysed use a quantitative analysis (92 per cent), while only 8 per cent (two studies) rely on qualitative analysis.

In terms of econometric methodologies, simple data analysis is the preferred method considering that it is complex/difficult to collect a long time series of data using questionnaires to build hypotheses and then test them. Even so, the content analysis could be another alternative when using qualitative data, but authors have only recently started using it (Wu *et al.*, 2018; Saura *et al.*, 2018). When using quantitative data, Table IV shows that the most applied methods are those of ANOVA, linear regression analysis and panel data models. Simple descriptive statistics are used in 80 per cent of the studies analysed, where correlation analysis and *t*-tests are also commonly applied to explore data properties. The use of χ^2 tests and reliability analysis is less common.

More complex econometric models are used when authors use quantitative secondary data (Tables II and III). These models allow having both a clearer picture of the quantitative

Table IV Dimensions of AQ

Type of study	*Dimensions AQ analysed*	*Authors*
Impact on individual visitors	Perceptions of environmental risks	Becken *et al.* (2017)
	Perceptions of AQ	Bohm and Pfister (2011), Hipp and Ogunseitan (2011), Law and Cheung (2009), Nejati *et al.* (2015) and Wu *et al.* (2018)
	Perceptions of haze pollution	Hill *et al.* (2000), Jun-hui (2018), Wu *et al.* (2018), Zhang *et al.* (2015) and Zhu (2018)
	Perceptions of factors related to atmospheric contaminations	Saura *et al.* (2018)
	Perceptions of ozone depletion	Bohm and Pfister (2011) and Hipp and Ogunseitan (2011)
	PSI, days of haze and visibility	Agarwal *et al.* (2018)
	Perceptions of fog	Jun-hui (2018)
	Perceptions of smog	Peng and Xiao (2018)
	PM	Pant *et al.* (2018) and Sato *et al.* (2016)
	Black carbon	Pant *et al.* (2018)
Impact on global tourism demand	Methane, nitrous oxide emissions	Sajjad *et al.* (2014)
	Air pollution index	Chen *et al.* (2017), Yan et al (2019) and Zhou *et al.* (2018)
	AQ index	Wang *et al.* (2018) and Yan et al (2019)
	haze-related air pollution	Anaman and Looi (2000)
	Industrial waste gas emission	Deng *et al.* (2017)
	Ozone pollution	Keiser *et al.* (2018)
	Carbon dioxide emissions	Liu *et al.* (2019) and Sajjad *et al.* (2014)
	PM concentrations	Liu *et al.* (2019)
	Visibility	Poudyal *et al.* (2013)

Figure 3 Geographical location of the study areas focussed and covered by the reference

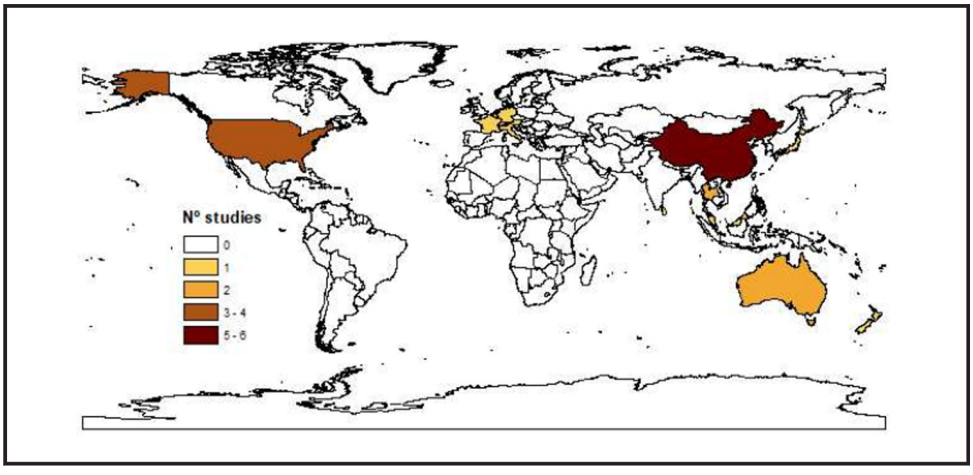
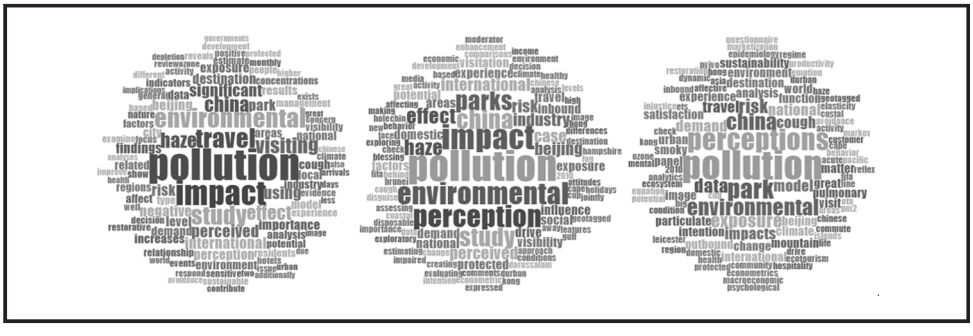


Figure 4 Word frequency represented by word clouds according to abstracts, titles and keywords



impact of AQ on tourism and economic growth, as well as development at national and regional levels. The analysis suggests that using secondary data panel models and time series models (like VAR) allows for a more complete analysis of the relationship between AQ and tourism. Content analysis, which has not been used, can be used together with other methods to perform a more in-depth analysis of the influence of AQ on the tourism demand.

Logit models, Poisson regressions, spatial models, structural equation models, corrected least squares dummy variable models, Markov regime-switching, contingency and polynomial distributed lag models are less commonly used among authors. Therefore, a lot of work remains to be done in econometric terms and more suitable models are necessary to examine the interaction between AQ and tourism at both national and regional analysis. For example, considering available monthly data, it will be possible to apply models able to capture simultaneous interactions between AQ variables and tourism variables, such as a vector autoregressive model (VAR) used by Sajjad *et al.* (2014). VAR is a stochastic process model used to capture the linear interdependencies among multiple time series, where all variables are simultaneously considered to be endogenous and exogenous. This model does not require as much knowledge about the forces influencing a variable as structural models with simultaneous equations; the only prior knowledge required is a list of variables, which can be hypothesized to affect each other intertemporally. Additionally, when considering regional or municipalities' analysis, panel VAR models are also suitable and possible to use. Finally, they allow testing dynamic data correlations by using, for

example, Granger causality. These models are particularly suited to address issues that are currently at the centre stage of discussions in academics and in the policy arena, as they are able to:

- capture both static and dynamic interdependencies;
- treat the links across units in an unrestricted fashion;
- easily incorporate time variations in the coefficients and in the variance of the shocks;
- account for cross sectional dynamic heterogeneities; and
- use Granger causality and capture more complex correlation analysis.

Moreover, more qualitative studies should be carried out in this field to examine the influence of AQ on the behaviour and experiences of tourists. Table IV evidences the limitations, thus, far in terms of methodology analysis and provides valuable future research directions.

3.6 Variables used

3.6.1 Dimensions of air quality. The variables used in the various studies to measure AQ and its impact on tourism differ, essentially, between studies that examine the impact of AQ on visitors and studies that analyse the impact of AQ on global tourism demand. In the first group, a great number of studies use the perception of AQ and the perception of haze pollution (Table IV). In a smaller number of studies, visitor perception of the environmental risks, atmospheric contaminations, ozone depletion, fog and smog are analysed. Additionally, other studies use measurements of variables related to AQ rather than visitor perception such as the pollution standard index (PSI), days of haze, visibility, particulate matter (PM) and black carbon.

Articles that analyse the impacts of AQ on global tourism demand are no longer based on perception but quantitative AQ variables. Most studies are based on indices of air pollution (or AQ). There is another subset of studies that are based on emission variables (e.g. CO_2, waste gases, methane, nitrous oxide and ozone). Moreover, there is a dispersion of studies that use other variables such as visibility, PM concentrations and haze.

3.6.2 Dimensions of tourism demand. The impact of AQ on tourism demand has been analysed through several approaches. Therefore, the analysed articles were categorized into two groups according to the impact of AQ on:

1. Individual visitors.
2. Global tourism demand.

In the first group, most of the studies examine the travel intention and destination choice. Moreover, the effect of AQ on tourism has also been analysed through the well-being and quality of life (QOL) variables (including physical and psychological health). A limited number of studies examined the impact of AQ on tourism experience, destination image, visitors' satisfaction and type of activities carried out during a trip. In the second group, the studies focus on global tourism demand, mainly on the size of tourism flows (e.g. tourist arrivals, number of visitors, departures, international tourism receipts and expenditures) (Table V). However, several dimensions of tourism demand have been neglected in these studies such as the impact of AQ on destination competitiveness, emotions, memorability and post-travel behaviours.

3.7 Impact of air quality on tourism

Because of the limited number of studies and due to the diversity of dimensions of AQ and tourism demand analysed, it is complex to draw many conclusions regarding the impact of

Table V Dimension of tourism demand

Type of study	*Dimensions of tourism affected by AQ*	*Authors*
Impact on individual visitors	Travel behaviour, travel intention and destination choice	Becken *et al.* (2017), Bohm and Pfister (2011), Hill *et al.* (2000), Jun-hui (2018), Law and Cheung (2009), Peng and Xiao (2018), Zhang *et al.* (2015) and Zhu (2018)
	Well-being and QOL	Bohm and Pfister (2011), Hipp and Ogunseitan (2011), Pant *et al.* (2018), Peng and Xiao (2018) and Sato *et al.* (2016)
	Visitors' satisfaction	Agarwal *et al.* (2018), Peng and Xiao (2018), Saura *et al.* (2018) and Wu *et al.* (2018)
	Destination image	Becken *et al.* (2017), Hill *et al.* (2000) and Peng and Xiao (2018)
Impact on global tourism demand	Tourist arrivals	Anaman and Looi (2000), Deng *et al.* (2017) and Zhou *et al.* (2018)
	Number of visitors	Chen *et al.* (2017), Keiser *et al.* (2018), Liu *et al.* (2019) and Poudyal *et al.* (2013)
	International tourism receipts and expenditures	Sajjad *et al.* (2014)
	Urban activities	Yan et al (2019)
	Outbound tourism demand	Wang *et al.* (2018)

AQ on tourism demand. However, some trends may be highlighted. Therefore, the most important results obtained in the papers reviewed in this article will be presented, categorized into two groups (Table V) as follows:

1. Papers that analyse the impact of AQ on individual visitors.
2. Papers that examine the impact of AQ on global tourism demand.

3.7.1 Impact on individual visitors. Results regarding the impact of AQ on individual visitors will be presented according to the dimensions of tourism demand considered in the studies:

- Travel behaviour, travel intention and destination choice;
- Well-being and QOL;
- Visitors' satisfaction; and
- Destination image.

3.7.1.1 Impact on travel behaviour, travel intention and destination choice. A deep analysis of the results reveals that good AQ is likely to have a positive influence on travel behaviour, travel intention and destination choice (Bohm and Pfister, 2011; Becken *et al.*, 2017; Hill *et al.*, 2000; Jun-hui, 2018; Law and Cheung, 2009; Zhang *et al.*, 2015; Zhu, 2018). This corroborates part of the findings of the literature review undertaken by Zajchowski *et al.* (2018) on the effects of good AQ on human behaviour. However, the variables representing AQ, the methodologies adopted and the tourism markets and destinations considered, vary across the studies. Zhu (2018), Zhang *et al.* (2015) and Hill *et al.* (2000) analyse haze effects on tourism in Beijing, while Zhu (2018) examines how the haze affects the travel wishes and decisions of Beijing residents. The results show that for the majority of the residents, hazy weather has an impact on their willingness to travel and means of travel. More than 80 per cent of the respondents are not satisfied with travelling during fog and haze days. Moreover, differences in terms of age were identified, with young people (under the age of 20) being more reluctant to travel on haze days. Zhang *et al.* (2015) also analyse the potential impacts of haze pollution on the tourism industry of Beijing, through a questionnaire applied to potential tourists of this tourism destination. The results obtained reveal that haze pollution affects tourist choice of destinations and departure time.

Differences are noticed among visitors with different travel purposes, with visitors travelling for sightseeing and leisure revealing a much higher concern regarding haze pollution than those travelling for business or visiting friends and relatives. Leading to visibility conditions that depend on haze affecting the likelihood of visiting the destinations in the future. Hill *et al.* (2000) analysed this topic for the White Mountain National Forest, NH (USA) and concluded that as visibility decreases, the probability of accepting visibility conditions tends to decrease and also that potential visitors planning a visit to the White Mountains in the future would be less likely to visit this protected area if the visibility conditions got worse. Finally, Jun-hui (2018) examines tourist perception of fog and haze in Xi'an (a world famous historical and cultural city in China). In this study, the tourists were categorized into three segments ("blunt type", "normal type" and "sensitive type") according to their perceptions of the fog and haze. Differences were obtained in terms of sociodemographic profiles and travel behaviour (before and during the trip). Tourists may not perceive the AQ conditions of the location they are visiting until they reach their home countries and feel the difference.

Other authors focussed on the tourist environmental risk perception and on the influence of this perception on present and future visits. Bohm and Pfister (2011) analyse traveller environmental risk perception in two tourism destinations with different environmental problems as follows: Australia (with ozone depletion) and Bangkok (with severe air pollution). Results show that travellers usually perceive lower risks than non-travellers, and that the decision to travel to environmentally afflicted destinations is related to people's anticipated emotional response. Becken *et al.* (2017) also reveals that, to American and Australian citizens, feelings towards the air (affective risk perceptions) also have a negative impact on intentions to visit China. Law and Cheung (2009) concluded this when analysing international visitor perception of AQ (both indoor and outdoor) in Hong Kong. Their findings reveal that the respondents generally do not perceive the AQ in Hong Kong as a concern when they select this country as a tourism destination, but after their visit they considered the AQ in Hong Kong worse than in their home countries. Moreover, the results also reveal that many of the respondents were willing to pay an additional departure tax to fund improvements in AQ.

3.7.1.2 Impact on well-being and quality of life. One set of studies (Bohm and Pfister, 2011; Hipp and Ogunseitan, 2011; Pant *et al.*, 2018; Sato *et al.*, 2016) analyses the impact of AQ on well-being and QOL. Environmental problems experienced during the trip may affect travellers' assessment of their QOL, as stated by Bohm and Pfister (2011) in a study based on Germans who travelled to environmentally afflicted destinations (Australia and Bangkok) and of Germans who did not travel. A study conducted in the California beaches by Hipp and Ogunseitan (2011), using objective and subjective measures of AQ, highlights the important impact of AQ on some aspects of visitors' QOL, through ordinal logistic models. The perceived AQ, measured using a scale from "very unhealthy" to "very healthy", has a significant positive influence on the perception of psychological restorativeness as a whole and four dimensions of this construct – fascination, coherence, compatibility and legibility. Moreover, visitors are much more likely to perceive a higher psychological restorativeness in days considered as healthy AQ, taking into account an objective measurement of ground-level ozone concentrations. This is noticed for restorativeness as a whole and to its five dimensions considered in the study – being away, fascination, coherence, compatibility and legibility.

The impact of the exposure to air pollutants perceived by tourists and their potential health risks was also a focus in some studies such as Pant *et al.* (2018) and Sato *et al.* (2016). The first study was carried out in Vietnam, concluding that the exposure of a tourist to air pollutants in Vietnam is lower than in cities in India and China. The second study was carried in China (Beijing) and confirmed the impact of short-term exposure to high concentrations of PM (PM 2.5 and PM 10) on tourist health, specifically on the cough reflex threshold, urge-to-cough and pulmonary function. Authors remark that a higher risk can

exist in the case of unhealthy and health fragile groups (e.g. elderly, children and people with asthma or other pulmonary diseases).

3.7.1.3 Impact on visitors' satisfaction Only four studies (Agarwal *et al.*, 2018; Peng and Xiao, 2018; Saura *et al.*, 2018; Wu *et al.*, 2018) examine the impact of AQ on visitor satisfaction. Factors influencing Chinese satisfaction with international self-drive holidays were analysed in Wu *et al.* (2018). AQ is one of the factors analysed. Findings show that for the Chinese drive tourists, AQ has a positive and significant effect on their overall travel satisfaction. Moreover, Peng and Xiao (2018) also observed that in the case of domestic tourists of Beijing, the perception of experience risk produced by smog could cause travel dissatisfaction. Furthermore, Agarwal *et al.* (2018) examine whether hotel review scores provided by guests travelling in Singapore and Hong Kong in three online platforms – TripAdvisor.com, Agoda.com and Expedia.com – are influenced by haze episodes. Serious haze episodes showed to have a negative impact on online review scores, which reveals a decrease on guest satisfaction levels. Saura *et al.* (2018) analysed tweets of 25 Spanish hotels on social media, with the aim of investigating the experience of hotel guests. The authors try to identify environmental factors among comments grouped into negative and positive, according to guest feelings. Environmental factors related to atmospheric contamination emerge with considerable frequency, among negative and positive tweets. This means that these features are relevant for hotel guests and can trigger positive feelings when people perceive a good AQ. On the other hand, when contamination exists and there are risks of asthma and other breathing problems, negative feelings emerge.

3.7.1.4 Impact on destination image. Despite that, theoretically, AQ is a relevant attribute to the competitiveness of tourism destinations, the research in this field is very scarce. Only the studies carried out by Becken *et al.* (2017) and Peng and Xiao (2018) investigate the impact of AQ on destination image. The model developed by Becken *et al.* (2017) is tested among Americans and Australians, and results reveal that feelings towards the air (affective risk perceptions) have a negative impact on both the cognitive and affective image of China. However, no significant differences are detected on feelings towards the risk of AQ between American and Australian citizens. Moreover, concerning China domestic tourists, the majority agree that smog has a negative influence on Beijing's image, as concluded by Peng and Xiao (2018).

3.7.2 Impact on global tourism demand. There are also studies that address the impact of AQ on tourism but at the macro level. That is, not analysing the individual decisions of the tourist, but looking at the tourism industry of a country or region or a specific tourism attraction (such as a natural park). A consensual conclusion is that air pollution reduces the number of tourists (Anaman and Looi, 2000; Deng *et al.*, 2017; Wang *et al.*, 2018; Sajjad *et al.*, 2014; Zhou *et al.*, 2018; Liu *et al.*, 2019; Keiser *et al.*, 2018; Yan *et al.*, 2019; Chen *et al.*, 2017). For instance, Anaman and Looi (2000), using two different methodologies, estimated that 1997 and 1998 haze-related air pollution in Brunei caused about 3.75 or 28.70 per cent reduction in the number of tourists and that the total direct economic loss suffered by the tourism industry was estimated to be about B$1m to B$8m (respectively, for each methodology). Furthermore, these negative economic losses and negative impacts on tourist demand are very reliant on the phases of business cycles (Chen *et al.*, 2017). Another example of clear evidence of negative impacts of bad AQ on tourists, as well as on human health, is the study of Keiser *et al.* (2018), for the USA national parks. They found a strong negative relationship between ozone concentrations and park visitation.

The impact of AQ on tourism can vary when different pollutants are analysed. For instance, Liu *et al.* (2019) concluded that carbon dioxide has no significant impact on tourism while PM 2.5 has a significant negative impact. The reason for this result may be that the effect of PM 2.5 on air is that its more perceptible compared to CO_2 (colourless and odourless). Yan *et al.* (2019) concluded that SO_2 has the largest impact on tourism demand, followed by PM 2.5, NO_2 and PM 10, while CO (carbon monoxide) and O_3 seem to have little influence.

Another interesting result comes from Zhou *et al.* (2018), who reveal that the negative impact on tourism is higher when pollution increases. For low levels of pollution, there are almost no perceived impacts, but as AQ further deteriorates, tourists become more alert to its adverse effect, and thus, the negative impact of air pollution occurs.

The impacts of AQ can also be different between domestic and international tourists (Liu *et al.*,2019), overnight visitors and one day visitors (Poudyal *et al.*, 2013), as well as visitors and local residents (Yan *et al.*, 2019). Liu *et al.* (2019) concluded that for China, domestic tourists are more sensitive than international tourists. The reason may be that international visitors are not able to perceive the AQ of China or have little or no information about this condition before travelling to the country. Poudyal *et al.* (2013) estimated elasticity for a national park in the USA, revealing that a programme aiming to improve the average visibility by 10 per cent (5.5 km) from the current level could result in an increase of about one million annual recreational visits. However, the increase would be higher for overnight visitors than for day visitors because the elasticity of tourism demand with respect to visibility was higher in overnight visitors. Yan *et al.* (2019) also estimated that the effect of pollutants is at least four times smaller on visitors than on local residents.

Time is also an important variable, as pollution worsens, the impact of pollution will last for a longer period and the degree of the impact in each time period will be more severe (Zhou *et al.*, 2018). Some authors identify a delay effect in the impacts of AQ on tourism demand (five days in the case of Wang *et al.* (2018) and one month in the case of Zhou *et al.* (2018). Poudyal *et al.* (2013) concluded that park visitations in a given month are significantly affected by the cumulative effect of the visibility condition in both the current and proceeding months.

Some authors have already indicated that the study of the impact of air pollution on tourism variables may be enriched with the introduction of some control variables such as tourism resource endowments, namely, the level of transport infrastructure, open-up degree, accommodation facilities (Deng *et al.*, 2017) or disposable income level (Wang *et al.*, 2018). Deng *et al.* (2017) also conclude that air pollution in nearby regions also affects local tourism, being the spillover effect (indirect effect) even larger than the direct effect.

4. Conclusions

A systematic review was performed to study the subject of impacts of AQ on tourism demand, analysing the different methods and approaches used to assess these impacts and the results obtained. A total of 26 papers were identified, with the majority published in the past decade (88 per cent) and quite restricted/focussed to China and Southeast Asia regions.

The reduced number of studies analysing the impact of AQ on tourism and the diversity of dimensions of AQ or tourism demand considered in these studies, make it difficult to draw conclusions on this kind of impact. However, some trends are observable. Both research on global tourism demand and on individual perceptions reveal that AQ tends to have a positive influence on tourism demand, with decreases in AQ leading to decreases in tourism flows or to a lower likelihood of visiting certain destinations.

The studies reviewed confirm that nobody would like to travel to those places where the environment is severely polluted. Compared with other environmental pollution such as water and soil pollution, air pollution is much more visible and can be perceived more easily by the public, which justifies the high impact that it may have on tourism in a given destination. Special attention should be devoted to avoiding high levels of pollution and bad conditions regarding AQ, as the impact of AQ on tourism tends to be higher when AQ is significantly reduced.

The results and conclusions of the present study can contribute to tourism management in similar destinations around the world. Hereby, more attention should continue to be devoted to inspecting the influences of any changes in atmospheric conditions on the demand for tourism, as extreme weather events are becoming more intense and more frequent.

Although some research studies have examined the negative impacts of air pollution on tourism, this important area of inquiry is still in its early stages and many critical issues have yet to be analysed and discussed. The most notable issues are how AQ influences the seasonality of tourism demand, tourism experience, attractiveness and competitiveness of tourism industry; and how it influences the magnitude and nature of the economic impacts of tourism industry. There is further lack of studies, which relate AQ impacts to population exposure (pollutant concentration multiplied by people and time). Therefore, more secondary data related to regional and national impacts of tourism activities has to be included into the analysis of the relationship between AQ and tourism. As previously mentioned, China and Asiatic countries have been extensively analysed under this issue. However, little is known about other regions and nations around the world where AQ levels are low or are significantly affected by high levels of air pollution.

Besides that, there is still a limited number of studies examining the role of AQ in the attractiveness and competitiveness of tourism destinations, and the question about the effects of AQ over tourism destination choices remains unanswered. Then, very little concern is devoted to good AQ and how the AQ index can become an important destination attribute influencing the attractiveness of tourism destinations.

Despite being a systematic literature review, this study has limitations that need to be addressed. The first is that the studies analysed, i.e. those focussed on the effects of outdoor AQ on tourism, are very scarce. This partially results from the option to only include studies focussed on outdoor AQ. As AQ is extremely linked to physical comfort and may have impacts on the tourist experience, future research should include studies on indoor AQ, providing the opportunity to strengthen the sample and to establish some comparisons between two different, but in a certain way, related matters.

Another limitation is the fact that most of the studies were focussed on Asian countries, with very few being conducted in other regions of the world. Although being an uncontrolled issue, there is an opportunity for future studies to be developed, helping to understand if the findings obtained in Asian countries are aligned and coherent with other regions, namely, in a context where environmental awareness is a growing phenomenon.

Finally, the option to only include papers in English can also be pointed out as a limitation, namely, because they may not be representative of all the evidence on the topic in analysis. Therefore, future research should be extended to included literature published in other languages.

Considering the great need of carrying out more studies, especially in other regions of the world beyond Asian countries, to ensure a sustainable development of tourism in the future, a wide plethora of methodological approaches may be adopted. As already mentioned, secondary data should be further explored. Moreover, mixed methodological approaches, including both quantitative and qualitative methods, should be privileged in further research to obtain a deeper knowledge of how AQ affects tourism demand and, consequently, the competitiveness of tourism destinations. Considering the environmental changes that have been occurring and that will take place in the future, longitudinal studies are also highly relevant to assess how the impact of AQ on tourism demand is changing and what kind of strategies should be designed to ensure sustainable development. The ongoing Portuguese research project ARTUR (http://projeto-artur.web.ua.pt) will address some of these concerns and its outcomes may help to increase the knowledge on both the environmental and tourism sectors, promoting both AQ protection and tourism sustainability.

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