SHORT TERM SCIENTIFIC MISSION (STSM) SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA16202
STSM title: Modelling dust event exposures for epidemiological studies for the short-term effects of desert dust on human health
STSM start and end date: 01/04/2019 to 19/04/2019
Grantee name: Prof. Masahiro Hashizume

PURPOSE OF THE STSM:

(max.200 words)
The summary of evidence for the health effects of desert dust still remains unclear. Epidemiological studies in Eastern Asia had mainly assessed the health effect on days with dust events in comparison with days without dust events. Whilst those studies conducted in Southern Europe had considered dust events as a modifier of the health effects of particulate matter (PM). Moreover, few studies considered independently the effects of natural and local sources for PM during dust events. However, there is a lack of evidence in other regions, like Northern Africa and/or the Middle East.

Therefore, there is an urgent need to design an epidemiological study protocol, with a time-series design, using the same definition of exposure to dust and evaluate with the same methodology their short-term effects on a commonly defined health outcome, in and near to hot spots with exposure to desert dust and sand storms worldwide.

The objective of the STSM agrees with the main aim of the inDust COST action (CA16202) to exploit dust monitoring observations best suited to be used in epidemiological studies to assess the health effects of desert dust on human health and to enhance the cooperation with institutions from near-neighbouring and partner countries affected by airborne mineral dust.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

(max.500 words)
We first reviewed the most common methods used to identify dust events, as a binary exposure suitable for epidemiological studies. However, these vary by region affected by airborne mineral dust.

i) Mediterranean: Desert dust advection days are identified using a combination of tools, including meteorological products, aerosol, satellite images and air masses back-trajectories.
ii) Middle East: The main criterion is based on the daily exceedance of PM10 concentrations.
iii) Eastern Asia: The identification of Asian dust storms is commonly done by the National Meteorological Agencies of each country, mainly based on visibility.
iv) Other regions: Multiple criteria have been used in the Caribbean, from aerosol measurements to visibility. In Australia, the Dustwatch project uses computer simulation to estimate the origin and geographic distribution of dust events. While in the US, dust storm events are reported in the U.S. National Weather Service storm database, from a variety of sources including emergency and law enforcement officials, sky warns spotters, damage surveys, media reports, etc.

Next, we also reviewed the methods to quantify airborne mineral dust, as a continuous exposure useful for epidemiological studies. Here, only two methods have been used.

i) The EU Reference Method: This methodology has been applied to quantify dust and anthropogenic PM10 loads in the Mediterranean region. Firstly, desert dust advection days are identified, as previously described. Next, for the dust days, an evaluation of PM levels at the regional and sub-urban background air quality monitoring sites is conducted. To ascertain desert dust contributions to PM10 concentrations, the method estimates the 30 days moving 40th percentile, after excluding dust days. For those days affected by dust, the estimated percentile value is assumed to be the theoretical background PM10 concentration if the dust event did not occur. Moreover, the dust contribution to PM10 is obtained by the difference between the measured PM10 concentration value and the estimated percentile value.
ii) LIDAR: This utilizes polarized laser light to recognize shape differences to distinguish dust particles from other air pollutants, which are generally spherical, and it is commonly used in Japan and South Korea. If the lower atmosphere is well mixed, the dust concentrations on the ground are similar to that between 120m-270m above ground.

However, a current alternative to in-situ observation is remote sensing. The WMO SDS-WAS Regional Centre for Northern Africa, Middle East and Europe generate ensemble multi-model product for dust concentrations at surface level. However, this does not cover the entire planet. To collect homogeneous data in all dust affected regions it will be necessary to use data from global reanalyses, like MERRA-2 updated by NASA.

Finally, we planned a pilot study collecting data available for dust exposures in four cities from each region mainly affected by airborne mineral dust (Mediterranean: Barcelona, Eastern Asia: Fukuoka, Middle East: Jerusalem, and the US: Phoenix), to assess their suitability for epidemiological studies.

DESCRIPTION OF THE MAIN RESULTS OBTAINED

We collected data available for dust exposures in Barcelona and Fukuoka, between 2013-2015. For each city, we identified those days with dust events and collected daily concentrations of PM10 (in Barcelona) and SPM (in Fukuoka) the regional and sub-urban background air quality monitoring sites. With these data, we derived the dust and anthropogenic (local) contributions to PM using the EU Reference Method. We compared the suitability of the method estimating both sources only using the PM10 concentrations from the sub-urban site. Finally, we collected dust concentrations at the surface level from MERRA-2.

Descriptive results are shown in Table 1. In Barcelona, the median dust contribution to PM10 estimated from the EU Reference Method is 6.3 ug/m3. When applying the method using data from the sub-urban site only, the median dust contribution to PM10 is somehow overestimated (10.4 ug/m3), although it shows a high correlation with the full method (r=0.67). While the median dust concentration from MERRA-2 is almost three times higher (18.4 ug/m3) showing a small correlation with the reference method (r=0.35). In Fukuoka, the median dust contribution to SPM estimated from the reference method is higher than in Barcelona, 55.0 ug/m3. When using data from the sub-urban site only, the dust contribution is similar (48.7 ug/m3), also showing a high correlation (r=0.65). However, the dust concentration from MERRA-2 is substantially smaller (5.5 ug/m3) with a poorer correlation (r=0.20). Data for Jerusalem and Phoenix have already been requested and we expect to receive them shortly to complete the pilot study.

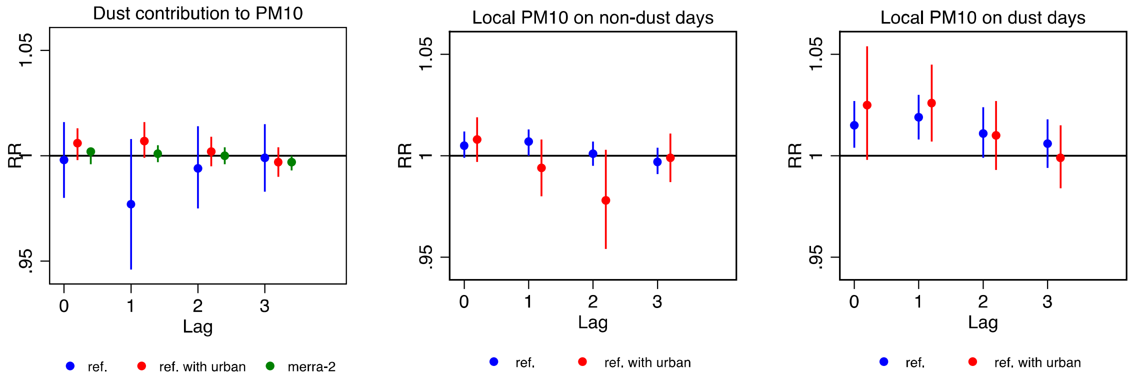
We also collected retrospective daily counts of mortality for all natural causes (ICD10: A00-R99) in Barcelona, between 2003-2010, already used in previous studies, to quantify the short-term effects of dust and anthropogenic (local) contributions to PM10. Figure 1 shows the risk of mortality for an increase of 10 ug/m3 of PM10, from the same day of the exposure (lag 0) and delayed effects up to four days after the exposure (lag 1 to lag 4). The dust contribution to PM10 does not increase the risk of mortality using any of the dust exposures estimated using the EU Reference Method, the reference method with data from the sub-urban site only and the dust concentration from MERRA-2 (Figure 1, left panel). The local contribution to PM10 during non-dust days shows a similar increase of risk the same day of the exposure (lag 0) using the EU Reference Method and the reference method with data from the sub-urban site only (Figure 1, central panel). Moreover, the local contribution during dust days shows a similar increase of risk for all lags using the EU Reference Method and the reference method with data from the sub-urban site only (Figure 1, right panel). Similar results were observed in Fukuoka (results not reported) showing a higher risk of mortality for the local contribution to SPM during dust-days, using both methods to source apportionment.

The results observed in Barcelona and Fukuoka suggest the suitability of the EU Reference Method in near-neighbouring and the inDust partner countries affected by airborne mineral dust. The method also seems to be robust to its application in locations where a regional background monitoring site is not available, but daily PM concentrations from a sub-urban site are obtainable. However, the use of reanalysis data, in our pilot study from MERRA-2, needs to be considered carefully. We need to check carefully jointly with the inDust Working Groups 1 (on identification and catalogue of dust ground-based and satellite observations) and 2 (on identification of the most suitable model products) the main charateristics of the models to derive dust concentrations from re-analysis and satellite observations in each location, to understand the reasons for the overestimation in Barcelona and understimation in Fukuoka and their suitability in other inDust partner countries affected by airborne mineral dust. Although, we should note the health effects obtained for the dust concentrations using re-analysis data were similar to those obtained for the dust contribution to PM using the EU Reference Method (Figure 1, left panel).

Table 1. Descriptive statistics for dust and anthropogenic contributions to PM10, in Barcelona and Fukuoka, between 2013-2015.

City/exposure	Median	Min.	Max.	Corr.
Barcelona				
ref.	6.3	0	102.5	
ref. with urban	10.4	0	84.5	0.67
merrra-2	18.4	.07	582.0	0.35
Fukuoka.				
ref.	55.0	13.3	119.9	
ref. with urban	48.7	11.9	77.1	0.65
merrra-2	5.5	.6	75.9	0.20

Figure 1. Short-term effects of dust and anthropogenic contributions to PM10 during dust and non-dust days, in Barcelona, between 2003-2010.



FUTURE COLLABORATIONS (if applicable)

The STSM has allowed establishing a research network involving the inDust partner countries affected by airborne mineral dust as potential end users of the information on dust exposures that can be suitable for health studies. The outcome provided in our study would be of great interest for the World Health Organisation (WHO) to develop, in collabotation with the inDust Working Group 4 (working on the transfer of dust products to user-oriented application in health studies), an standardized protocol to conduct future epidemiological in other regions affected by high concentrations of airborne mineral dust.

In this framework, we plan to keep our collaboration by developing the following actions to enhance the cooperation with:

i) Institutions from inDust near-neighbouring countries affected by the presence of airborne mineral dust, especially in South Korea and China, to involve them to collaborate actively with the inDust network to collect data on dust ground-based ans satellite observations (WG1) and health outcomes (WG4).

ii) The Multi-city Multi-Country Collaborative Research Network (http://mccstudy.lshtm.ac.uk/) to conduct a multi-centre study to assess the short-term effects of desert dust on human health in regions affected by airborne mineral dust (Portugal, Spain, France, Italy, Greece, China, Israel, Iran, Taiwan, South Korea, Japan, Australia and the US). This future study, using homogeneous data for dust exposure events, would help to clarify the evidence on the health effects of desert dust worldwide.
iii) The WHO and WMO to develop standardized protocols to conduct epidemiological studies for the short-term effects of desert dust (with WHO); and to harmonise an homogeneous data measures of airborne mineral dust (with WMO).