2019 Advanced Institute on Health Investigation
and Air Sensing for Asian Pollution (AI on Hi-ASAP)
September 2 – 6, 2019
Academia Sinica, Taipei, Taiwan

Exposure Health Relationship Evaluation

Shih-Chun Candice LUNG 龍世俊

- Research Center for Environmental Changes, Academia Sinica, Taiwan
- Center for Sustainability Science, Academia Sinica, Taiwan

Objectives of Exposure Health Relationship Evaluation in Hi-ASAP

- to assess the acute $PM_{2.5}$ damage coefficients of exposure-health relationship and to provide scientific evidences to set criteria or ceiling levels of $PM_{2.5}$ with shorter exposure periods (ex. seasonal, 8-hour or hourly)

Background for Hi-ASAP (1)

- Among the 2.2 million air pollution-related deaths in the Asia and the Pacific region in 2016, 29% were due to heart disease, 27% stroke, 22% chronic obstructive pulmonary disease (COPD), 14% lung cancer and 8% pneumonia
- Chronic health impacts such as COPD and lung cancers are associated with long-term exposure
- Acute health impacts such as asthmatic attack and irregularity of heart conditions (may lead to stroke or other heart diseases) are directly associated with peak exposures, which is difficult to measure up to now
- Currently, there is no guidelines or standards for short-term (seasonal, 8-hour or hourly) limits or ceiling values of $PM_{2.5}$ exposures due to lacking of scientific evidences
  - Since Asian people are exposed to much higher levels of $PM_{2.5}$ compared to the rest of the world population, Asian population are in need of such a short-term guideline/standard to reduce their health risks
- Emerging new technology such as low-cost sensors (LCS) may assist Asian scientists to tackle the challenges and provide scientific evidences to set short-term standards to reduce health risks of acute effects

Background for Hi-ASAP (2)

- In order to conduct **international comparison,** the damage coefficients of exposure-health relationship of peak exposures should be evaluated with **the same (or similar) methodology**
- Panel-type of epidemiological design to recruit general public will be adopted to assess the acute changes of health indicators due to short-term $PM_{2.5}$ exposures
- The approval of institutional review board (IRB) in your research organizations should be obtained
  - Data sharing to international teams should be specified in the IRB application as mentioned in the DATA POLICY of Hi-ASAP
- Traditional evaluation methods such as Peak Expiratory Flow (PEF) and newly developed wearable sensors for health indicators are both welcome as long as they are scientifically sound
- The evaluation of sensors should be conducted prior to the evaluation of the exposure-health relationship unless the device is a medical-certified one
  - Sensors compared with medical-certified devices obtaining good quality results are acceptable for research
  - QA/QC data needs to be transparent and shared among participating team members

Required Tasks in Exposure Health Relationship Evaluation in Hi-ASAP (1)

- Conduct concurrent assessment on $PM_{2.5}$ exposure and health indicators of the recruited subjects with LCS devices for at least 48 hours (or working hours of two working days)
- Assess health indicators of either lung function or heart conditions; Other health indicators are optional
- Conduct face-to-face interview with subjects for a questionnaire to obtain necessary information for subsequent data analysis
- have the same sample size in different seasons; to have the same subjects if possible
  - "Season" in different study areas could be defined differently with clear descriptions

Required Tasks in Exposure Health Relationship Evaluation in Hi-ASAP (2)

- Options for wearable health sensor devices:
  - Rooti, for heart rate variability (HRV), is a medical-certified device. (Karaoguz et al., 2019; Journal of Electrocardiology for the details)
  - Smart watches may also have potentials to obtain quality data for $PM_{2.5}$ exposure-health relationship evaluation
  - QA/QC data of the device used in the Hi-ASAP should be provided by the end of 2019 so that the team members could choose the ones that fit with the main objectives and budget in their study area

Exposure Health Relationship Evaluation Methodology for Hi-ASAP (1)

- (a) Subject recruitment:
  - subjects are the same as those recruited for exposure-health relationship evaluation. The proposed subjects are non-smoking subjects in communities or from certain occupational groups without pre-existing heart diseases and asthma who will at least go out 1-2 hours (expected outdoor exposure sources: traffic, home factories, or opening fire) and perform cooking, incense-burning, mosquito-coil-burning or any type of combustion activity every day
- (b) Sensor wearing for exposure assessment
  - subjects will wear portable $PM_{2.5}$ LCS devices for 2-7 days (minimum requirement: 48-hour or working hours of two working days)
  - sensor measurements for heart-rate assessment and/or tests for lung condition evaluation should be conducted at the same days
  - subjects will be asked to fill out a questionnaire for personal characteristics as indicated in exposure-health evaluation

Exposure Health Relationship Evaluation Methodology for Hi-ASAP (2)

- (c) Evaluation for lung conditions (optional):
  - lung conditions of the subjects will be assessed every day for 2-7 days (at least 48 hours or working hours of two working days)
- (d) Fill out questionnaire:
  - subjects will be asked to fill out questionnaire with roughly 100 questions for their personal characteristics, household conditions, habits, social-economic status, etc. In order to compare the results internationally, the core questions in the questionnaire should be almost identical and will be provided by Candice Lung's group
- (e) Compensation:
  - Compensation to subjects is a standard practice in epidemiology for their time and effort to carry out the aforementioned tasks. The amount would be different in different countries. Each research group should find out later the required amount and indicate in your proposal and IRB application when applying funding to conduct such a study

Exposure Health Relationship Evaluation Methodology for Hi-ASAP (3)

- (f) IRB approval:
  - Obtaining approval from Institution review board (IRB) is a must for this study to be valid and publishable. Each research group should obtain IRB approval in your institute before implementation of any subject-related activities. In project description document for IRB, it should be indicated that **after de-identification, data will be shared with all international team members for scientific discussion and publications.** Failure to include this statement in the IRB application will lose the qualification of joining this Hi-ASAP team

- (g) Data analysis:
  - $PM_{2.5}$ damage coefficients of the exposure-health relationship will be assessed and compared between different seasons, among different types of communities, and among different areas. Since there is no threshold from $PM_{2.5}$ health effects, it is important to use statistical analysis to assess potential guideline value of $PM_{2.5}$ with shorter exposure periods. The needed statistical methods needed will be taught during the training workshops

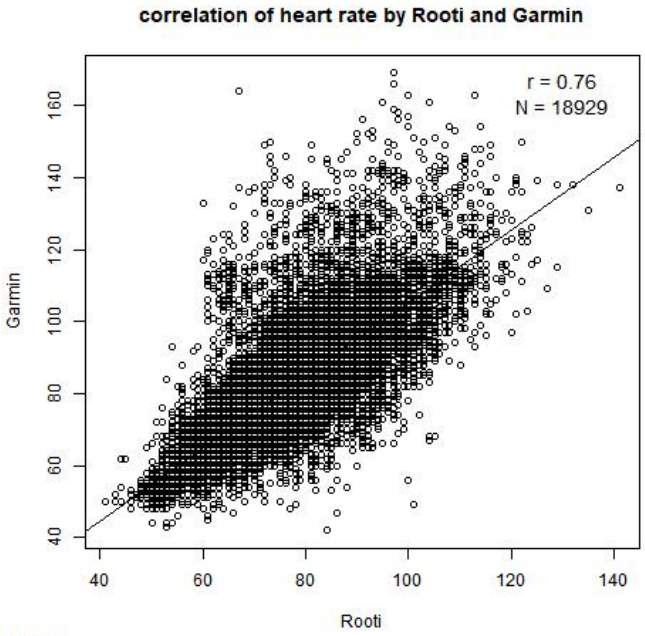
Consideration for Subject Selection Criteria in Hi-ASAP

- (a) good personality
- (b) wide ranges of $PM_{2.5}$ exposures so that the exposure-health evaluation can be evaluated
  - at least go out 1-2 hours (expected outdoor exposure sources: traffic, home factories, or opening fire) and perform cooking, incense-burning, mosquito-coil-burning or any type of combustion activity every day
- (c) susceptible population without pre-existing heart diseases and asthma
  - Elderly (above age of 40) or certain high-exposure occupational groups
  - non-smoking is preferred (or they are all smokers)
- (d) people can write TADs on their own and answer questionnaire honestly

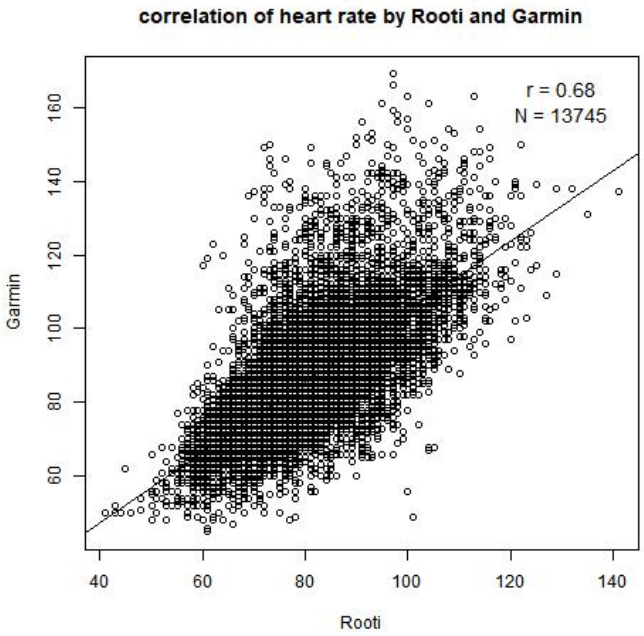
Comparison of Rooti and Smart Watch

- Two types of comparison
  - Heart rate (HR) from Rooti versus HR from smart watch
  - Evaluation of $PM_{2.5}$-HR relationships with HR from Rooti versus with HR from smart watch

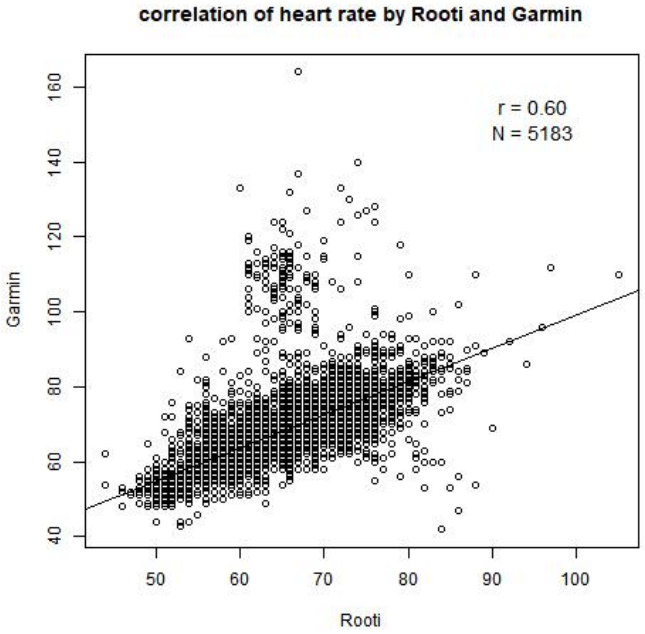
Correlation between HR from Rooti and smart watches



Awake time



Sleep time



Case Study (will be submitted to journals soon)

- Objectives: assess impacts of $PM_{2.5}$ on HRV
- Recruit 36 subjects (age of 40-75), non-smoking without pre-existing heart diseases and asthma
- at least go out 1-2 hours (expected outdoor exposure sources: traffic, home factories, or opening fire)
- perform two types of following activities:
  - cooking, incense-burning, mosquito-coil-burning or any type of combustion activity every day

Subject Description

(a)

Characteristics	$PM_{2.5}$			SDNN			LF/HF		
	Mean	**SD**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**n**
Gender									
Male (13)	12.8	11.1	7047	60.8	25.9	7047	2.56	2.28	7047
Female (20)	13.5	8.7	13820	66.4	29.1	13820	1.51	1.43	13820
Age (year)									
<30 (16)	12.8	9.2	9862	59.8	24.8	9862	2.2	2.2	9862
30~44 (10)	14.3	11.0	5868	67.6	27.3	5868	1.8	1.5	5868
=45 (7)	12.8	8.4	5137	70.0	33.3	5137	1.4	1.3	5137
BMI (kg/M^2)									
<24 (21)	12.9	9.4	13051	67.9	28.8	13051	1.6	1.6	13051
=24 (12)	13.8	9.8	7816	58.9	26.2	7816	2.3	2.1	7816
Season									
Summer(28)	12.7	10.2	9427	61.9	28.7	9427	2.0	1.9	9427
Winter (31)	13.7	9.0	11440	66.7	27.6	11440	1.7	1.8	11440
Area									
Northern(21)	12.8	9.4	12941	65.6	28.8	12941	1.7	1.6	12941
Central (4)	11.3	8.2	2590	59.6	25.1	2590	2.4	2.8	2590
Southern (5)	18.7	9.9	3487	63.5	27.1	3487	2.1	1.7	3487
Eastern (3)	8.8	7.5	1849	65.8	29.0	1849	1.7	1.6	1849
Activity Intensity (mG)									
<1500	12.6	8.9	5022	53.5	23.9	5022	1.9	1.9	5022
=1500	13.4	9.8	15845	68.0	28.6	15845	1.9	1.8	15845
Micro-environment									
Indoor	13.0	9.5	19807	64.6	28.2	19807	1.9	1.8	19807
Outdoor	17.5	9.4	1060	63.1	28.5	1060	2.0	1.8	1060

$PM_{2.5}$-HRV relationship
for LF/HF with General Additive Mixed Model (GAMM)

(b)	**Coefficient estimates**	
	Main model[a]	**Threshold model[b]**
	Adjusted R^2=0.131	Adjusted R^2=0.130
$PM_{2.5}$	3.86 (2.74 to 4.99)***	2.55 (0.60 to 4.53)**
Gender	60.3 (21.8 to 111)***	59.3 (21.1 to 109)***
BMI	26.3 (-3.31 to 65.0)	26.7 (-2.99 to 65.3)
Outdoor	7.71 (3.39 to 12.2)***	8.79 (4.43 to 13.3)***
Season[d]	-9.55 (-12.4 to -6.57)***	-9.38 (-12.3 to -6.38)***

Note: ***: p <0.001; **: 0.001< p <0.05; *: 0.05< p <0.1

[a]: $PM_{2.5}$ was treated as a continuous variable; BMI <24 was coded as 0 while BMI=24 coded as 1

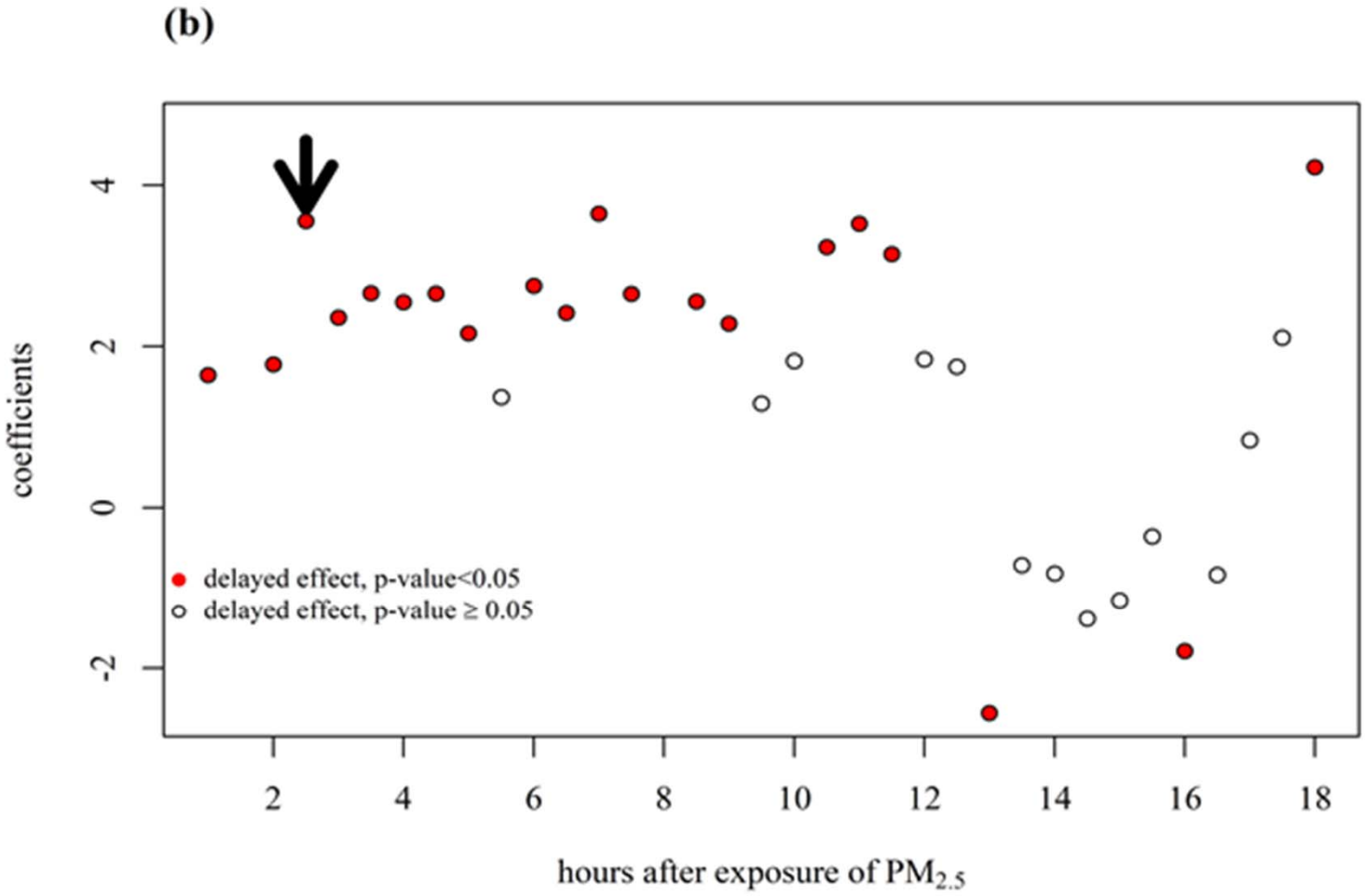
[b]: "$PM_{2.5}$ minus 30" was put in the model with negative values treated as 0; BMI<24 was coded as 0 while BMI=24 coded as 1

[c]: Both $PM_{2.5}$ and BMI were treated as continuous variables

[d]: Season was coded as 1 for November to April and as 0 for May to October

Delayed Effect

(for LF/HF)



Coefficients were plotted for every half hour; some coefficients were not shown since the model was not converged

Exposure Health Evaluation Consideration

- Lung function evaluation
- Hospital records with community central sites
- Other considerations
  - Ethical
  - Ethnical
  - …

Exposure Health Relationship Evaluation

Any questions?

Shih-Chun Candice LUNG 龍世俊

Research Center for Environmental Changes, Academia Sinica

Center for Sustainability Science , Academia Sinica

Sc.D, Harvard University, School of Public Health