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Ministry Of Health

Environmental Health in Kuwait: Past, Present, and Future

Barrak Alahmad, MD, MPH, PhD

Precision Medicine: Promoting Knowledge Exchange and Collaboration
between Kuwait and the United States - Second Workshop

October 15, 2025

NATIONAL
ACADEMIES
*Sciences
Engineering
Medicine*

DISCLAIMER + DISCLOSURE

This work was funded by government institutions in the United States and Kuwait.

The views that are presented in this talk are those of the author and do not necessarily represent the official positions of the State of Kuwait nor the United States Government. The material presented is not intended to be used for any international compensation claims.

I serve as a consultant and advisor for the **United Nations (UN) Habitat – Iraq and Kuwait Programs**

Kuwait Oil Fires

April 1991

May 1991

Image taken by Jack Heller, USACHPPM

Image by Earth Science and Remote Sensing Unit, NASA Johnson Space Center
Space Mission: [STS037-152-91](#)

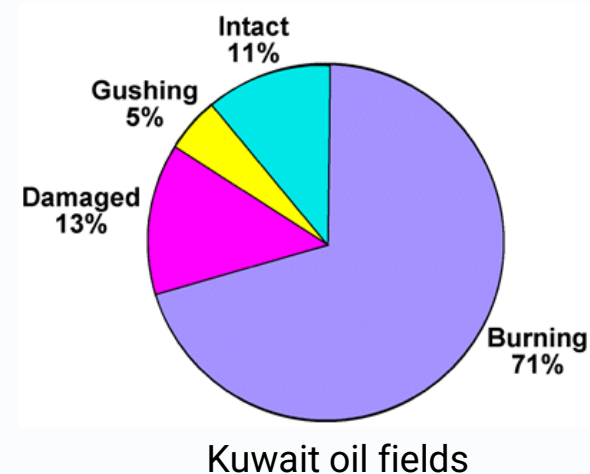
Kuwait Oil Fires

Timeline

- **Air War:** 17 Jan 1991
- **Ground War:** 23 Feb 1991
- **Liberation:** 28 Feb 1991
- **Last Fire Extinguished:** 6 Nov 1991

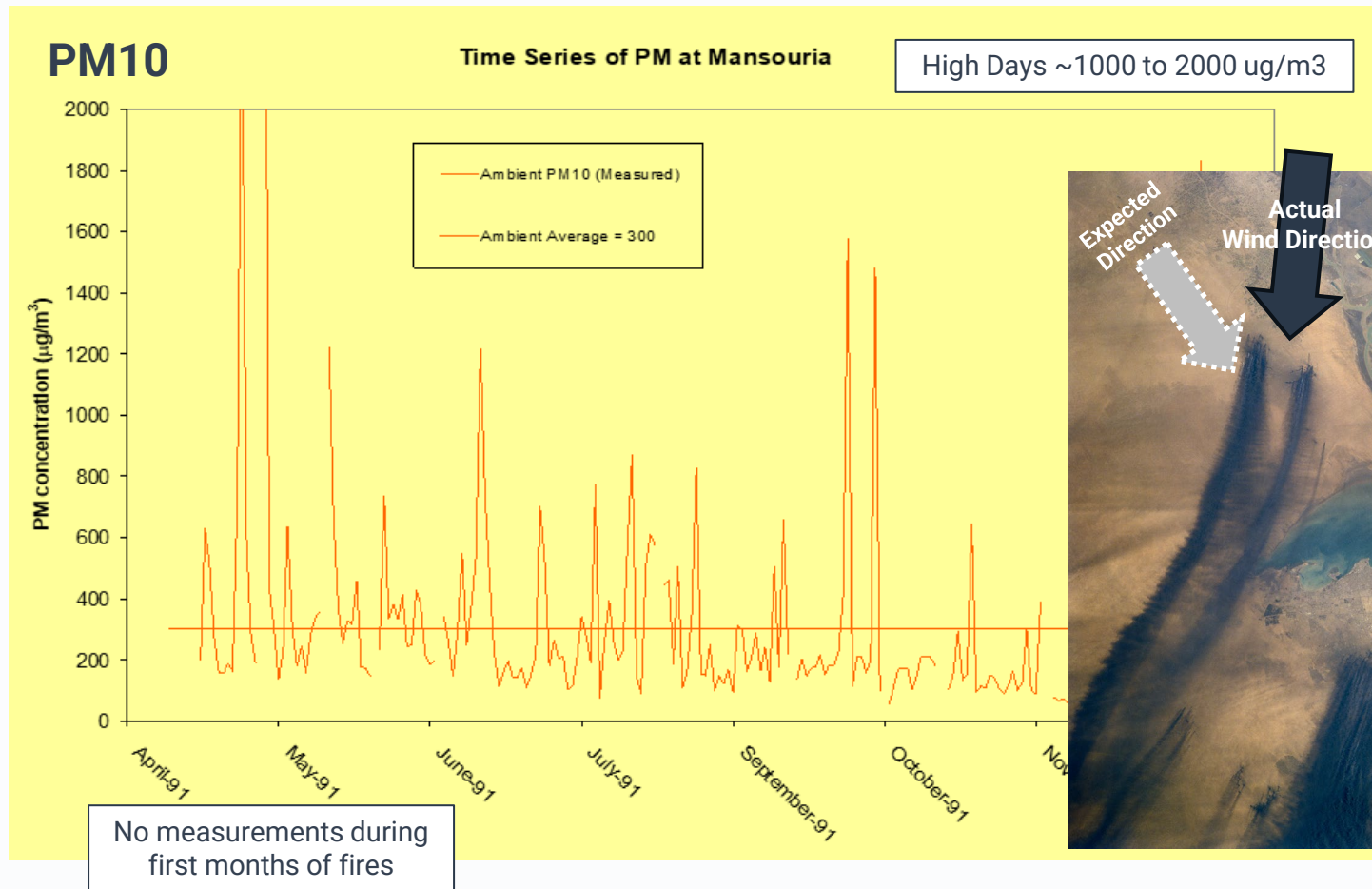
Scale:

- **Oil wells on fire:** ~700 wells
- **Oil burned:** $\sim 4 \times 10^6$ barrels/day
(~\$250m/day in today's money)
- **Particulate matter emission:** $\sim 3 \times 10^9$ kg
- **Total oil released:** $\sim 1-1.5 \times 10^9$ barrels
- **Total oil on land:** $\sim 25-40 \times 10^6$ barrels
- **Total oil flowing to sea:** $\sim 11 \times 10^6$ barrels
(twice more than Deepwater Horizon)

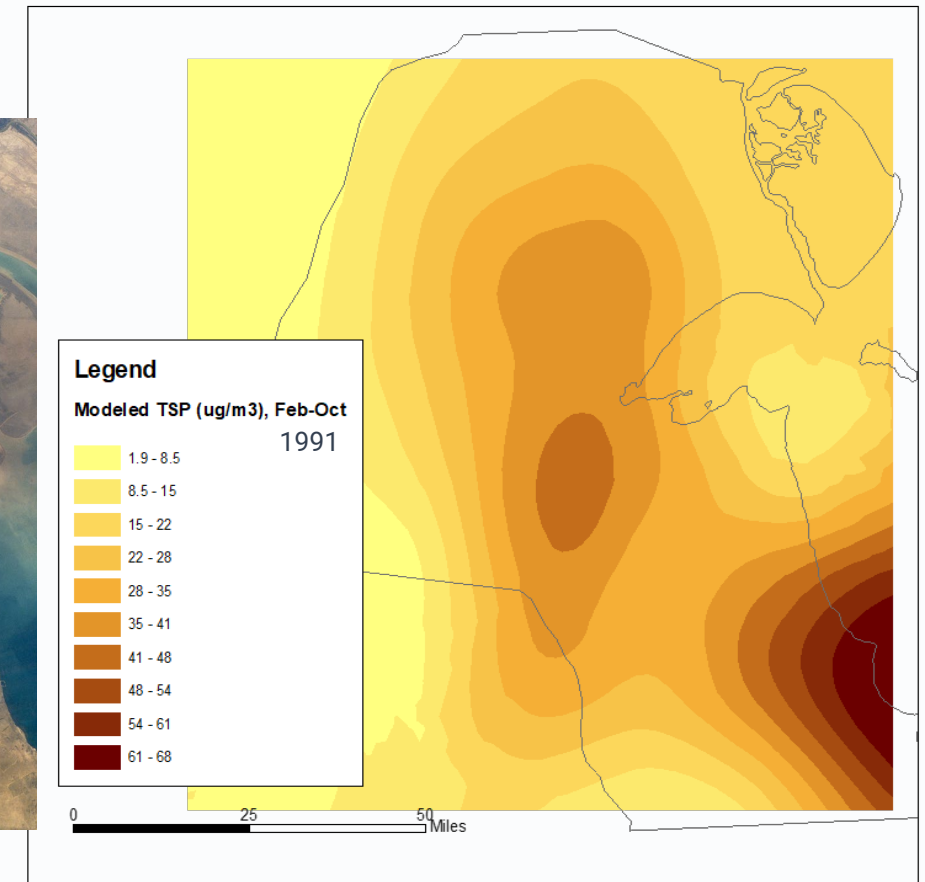


Kuwait Oil Fires: What's the Exposure?

Equipment had been stolen or destroyed (except 1 intact in *Mansouriya*)



US DOD Used a Model to Estimate Exposure of Allied Troops – **Harvard obtained results by Freedom of Information (FOIA) Request:**



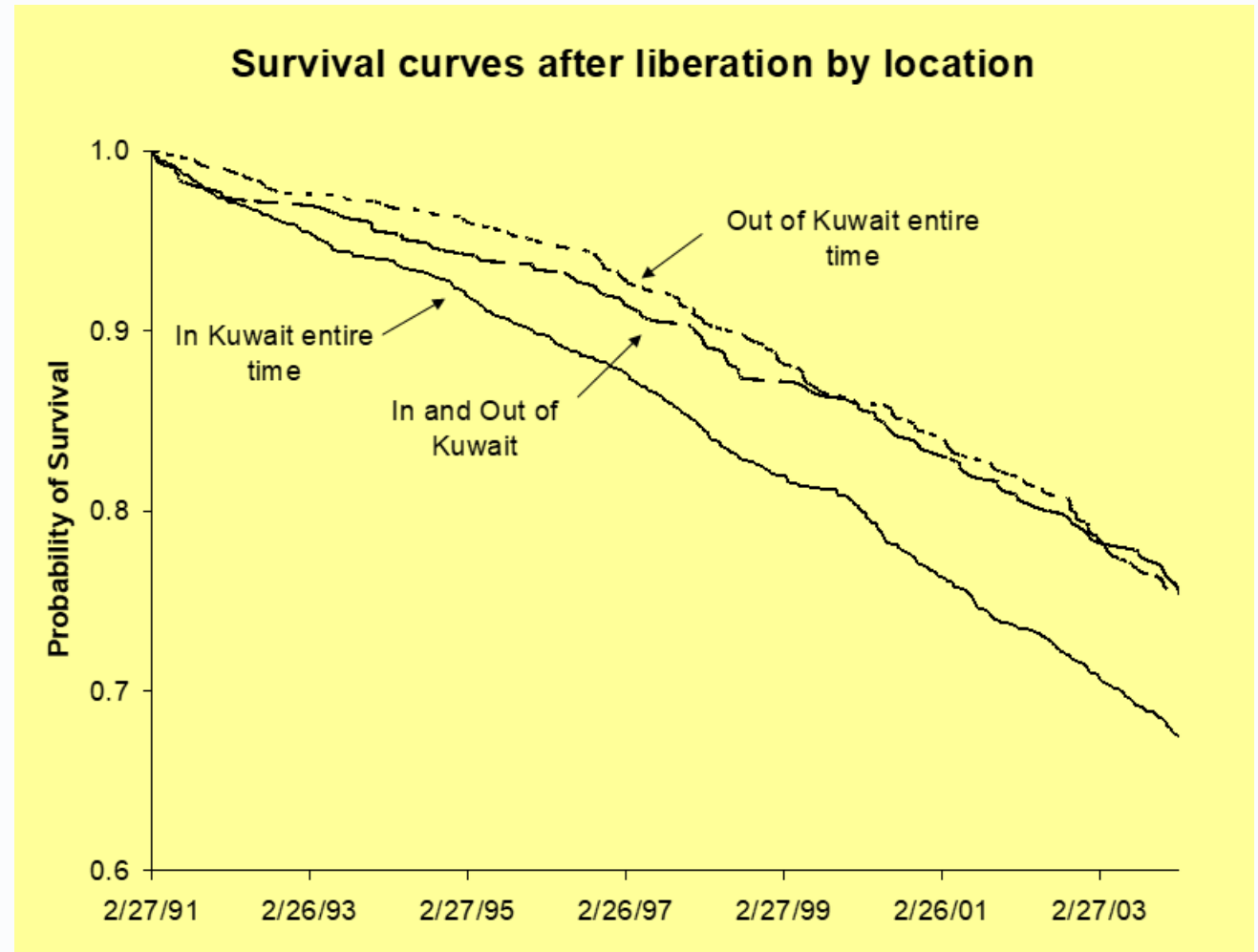
Iraq Invasion: Epidemiology

Harvard conducted a cohort study:

- ~5000 Kuwaitis
- Age 50+ yrs on the eve of Iraq's invasion
- Follow up from 1991 to 2003

Survival was **20-30%** lower for those in Kuwait the entire time **vs.** out of Kuwait during the occupation

This difference was statistically significant and persisted after control for age, smoking, income and education.



Iraq Invasion: Epidemiology

Al-Riggae Center conducted a cohort study:

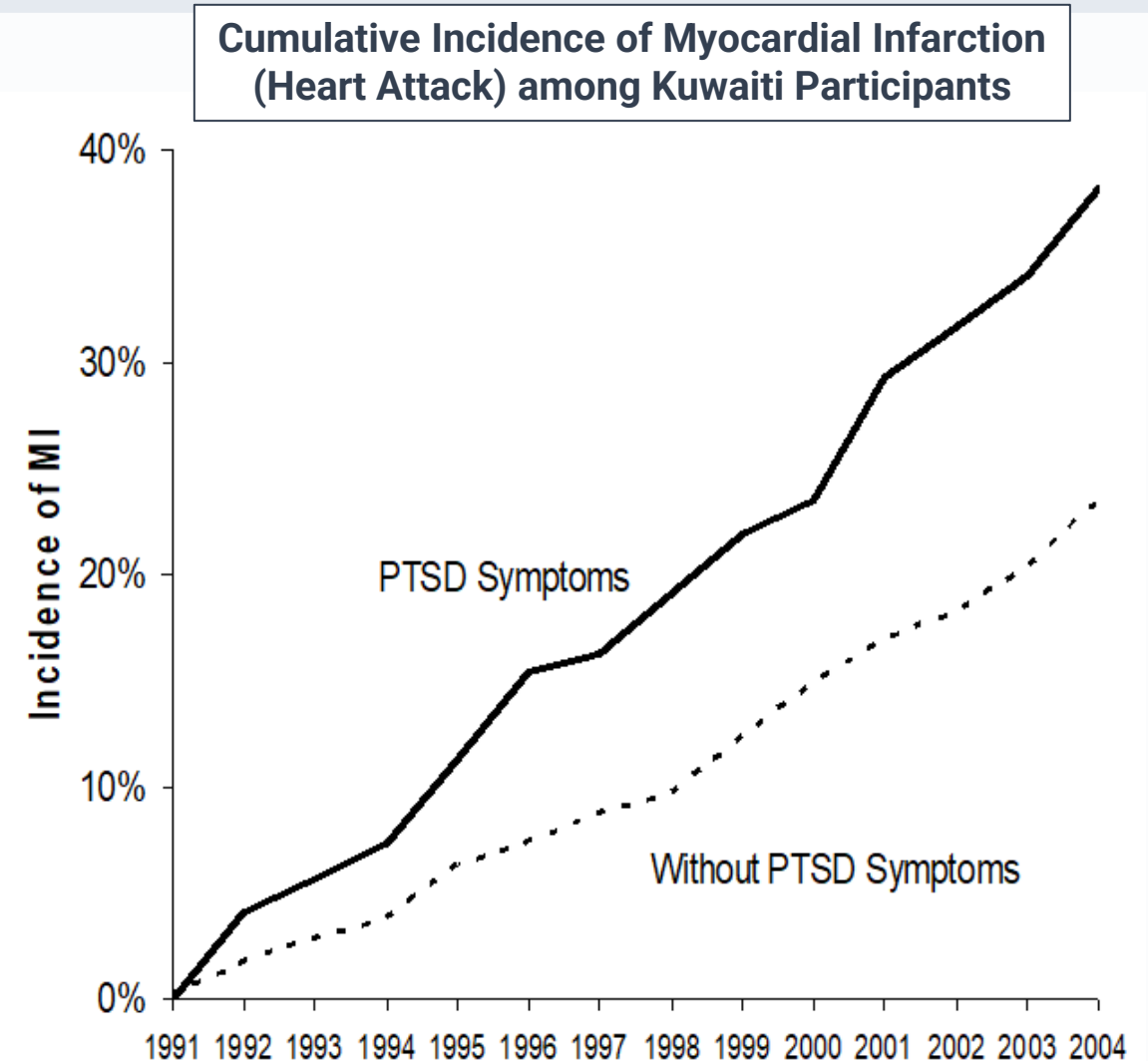
- ~2000 Kuwaiti Adults
- Follow up from 1993 to 2004

Post Traumatic Stress Disorder (PTSD)
diagnosed clinically as:

- *Troubled by unwanted memories or vivid dreams*
- *Avoid things which remind you of the past*
- *Feel emotionally numb*
- *Irritable or “on edge”*

Prevalence of PTSD at Baseline:

- In Kuwait entire time = **25.2%**
- In and Out of Kuwait = **20.5%**
- Out of Kuwait entire time = **14.4%**



FAST FORWARD

1995

Kuwait EPA



Established in 1995 amidst the oil lakes cleanup

2015

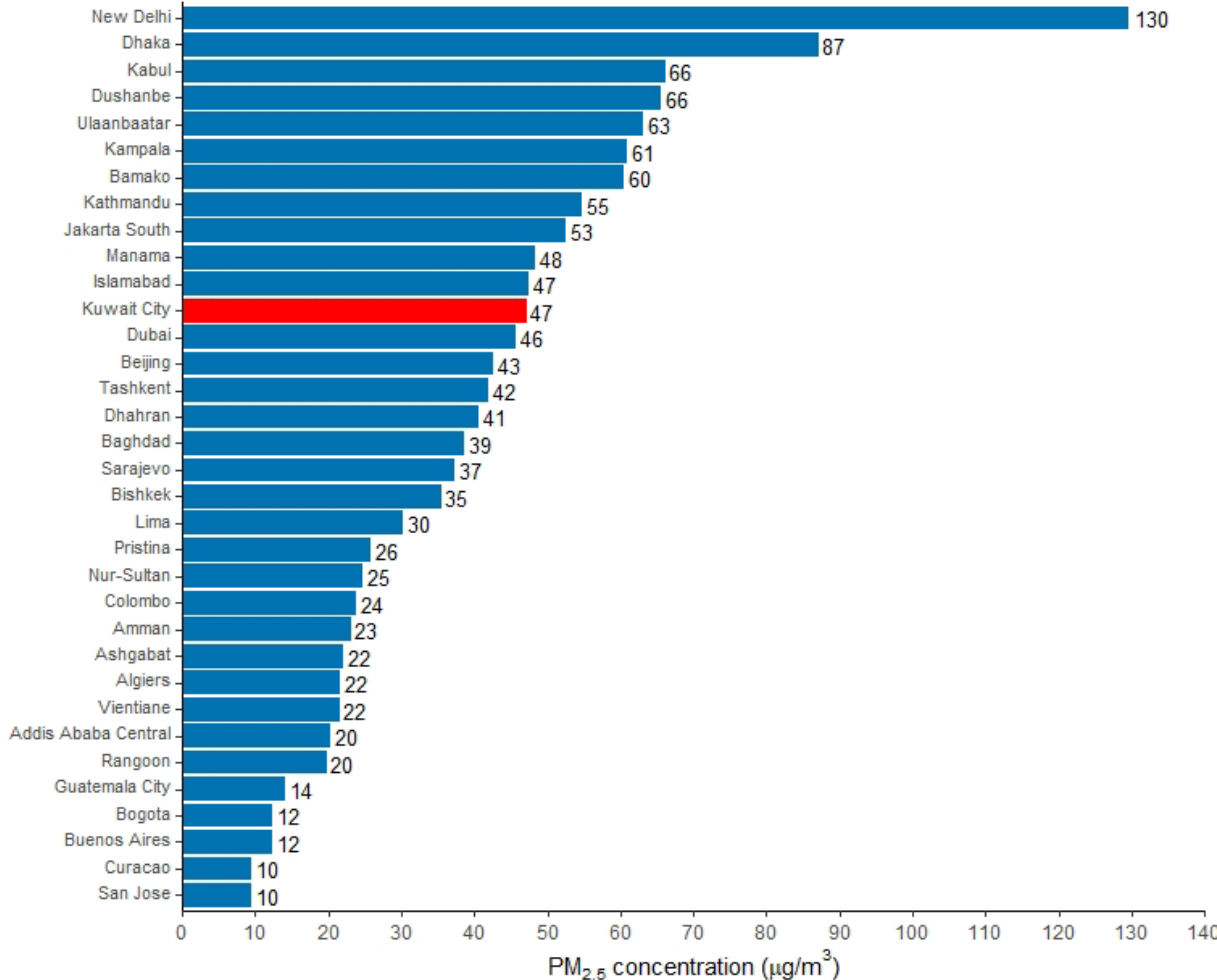


Environment Protection Law (#42/2014)
And its Amendment (#99/2015)

- Sweeping powers to EPA to regulate without Parliament
- Expanding scope:
 - **Air, water, soil, biodiversity, waste, ecosystem**
- Environmental Impact Assessment for any new project
- Hefty penalties

Air Pollution

Average PM_{2.5} at Selected U.S. Embassies in 2019



Kuwait Air Pollution Standards

الملاحق

الجدول رقم (1 - أ)

معايير جودة الهواء الخارجي لدولة الكويت للملوثات المرجعية

Criteria Pollutants

No.	Pollutant	Averaging Time	Limit	Classification Method
1	SO ₂	Hour	75 ppb	A
		24 Hour	19 ppb	B
2	NO ₂	Hour	100 ppb	A
		Annual	21 ppb	C
3	CO	Hour	35 ppm	D
4	O ₃	8 Hour	70 ppb	A
5	Pb	Quarterly Average	0.15 µg/m ³	C
6	PM ₁₀	24 Hour	350 µg/m ³	A
7	PM _{2.5}	Hour 24	75 µg/m ³	A

A- 99th percentile of maximum concentration over one year.

B- Not exceed more than 1 time per year in the same location.

- Standards came out in **2017**
- Kuwait EPA did **not** include an annual standard for PM_{2.5} and PM₁₀

Dust Storms in Kuwait

Annual average of
dust deposition

Kuwait City

270

tons/km²/year

One of the highest
totals of any city in
the world

Al-Dousari et al., 2013
UN Environment Program, 2016



Wafra Highway

June 17th 2021 at 5pm

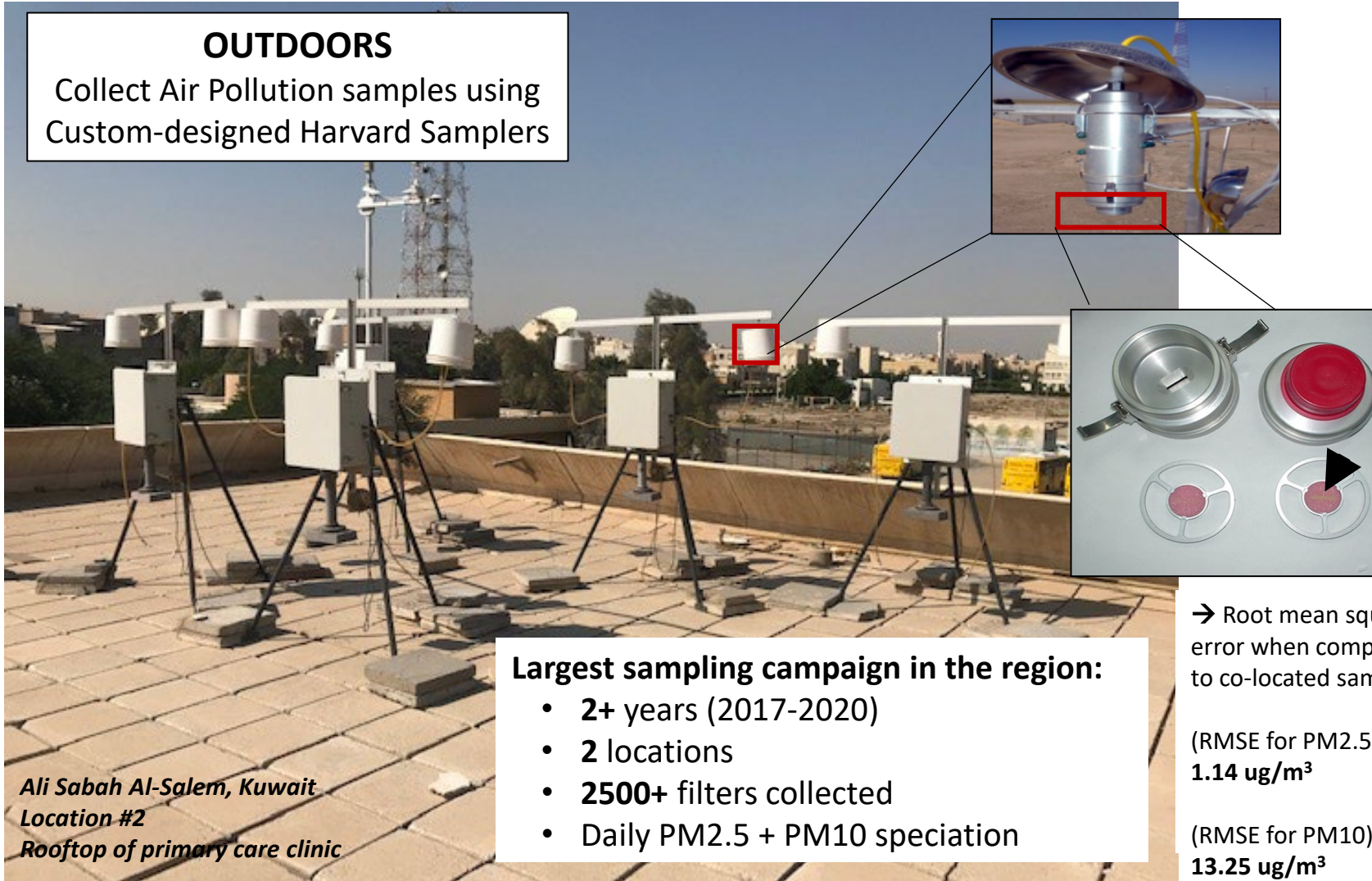


Image by Ali Al-Hemoud

Harvard Study 2.0

OUTDOORS

Collect Air Pollution samples using Custom-designed Harvard Samplers



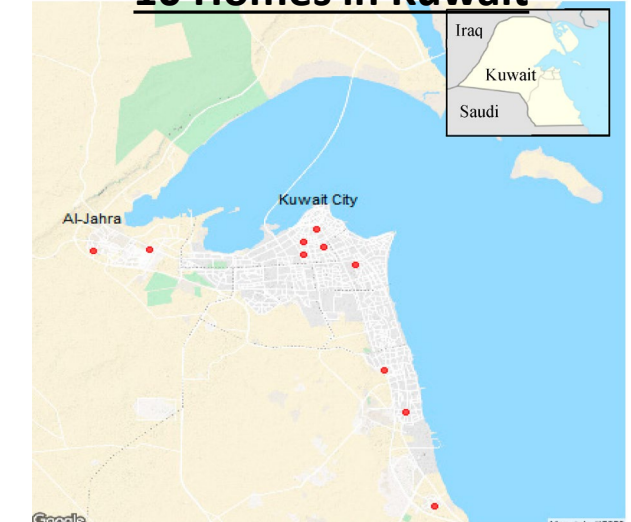
*Ali Sabah Al-Salem, Kuwait
Location #2
Rooftop of primary care clinic*

Alahmad et al. 2021

INDOORS

Collect Air Pollution samples using Custom-designed Harvard Samplers

10 Homes in Kuwait



Inside home



Outside home

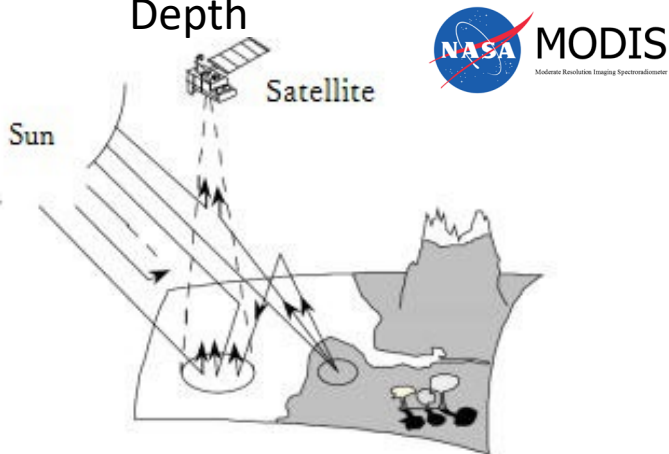


New Database for Air Pollution in Kuwait

Use a proxy for pollution



Aerosol Optical
Depth

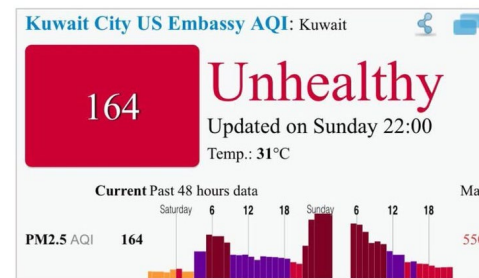


Ground Truth

Harvard Monitors

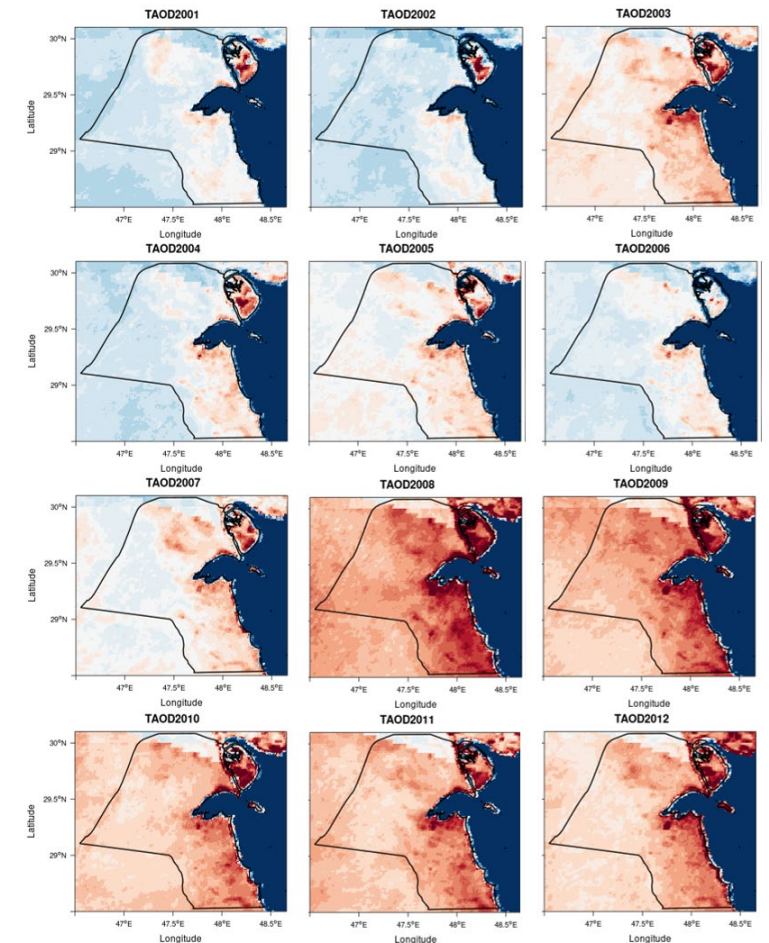


US Embassy data (adjusted)



Train Model

Predicted PM_{2.5}
For every 1 x 1 km
Every day 2001-2018



Air Pollution Effects on Health in Kuwait

Respiratory Admissions in Kuwait (2010-2019)

360

Excess hospital admissions per year
For 10 $\mu\text{g}/\text{m}^3$ in daily PM_{2.5}

Attributable respiratory hospitalizations per year from each 1 $\mu\text{g}/\text{m}^3$ increase in total daily ambient PM_{2.5} for total and subgroup populations in Kuwait.

Population group	Cases	95% CI
Total	36 	(12, 60)
Male	20	(3, 36)
Female	16	(2, 31)
Kuwaiti	26	(7, 45)
Non-Kuwaiti	10	(-2, 23)
<15 years	14	(-4, 32)
15+ years	22	(8, 37)

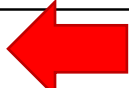
Note: Estimates in bold are statistically significant (when $\alpha = 0.05$).
Abbreviations: CI, confidence interval.

Respiratory Admissions in Kuwait (2017-2019)

1.6%

Excess hospital admissions per year
For 10 $\mu\text{g}/\text{m}^3$ in daily dust PM_{2.5}

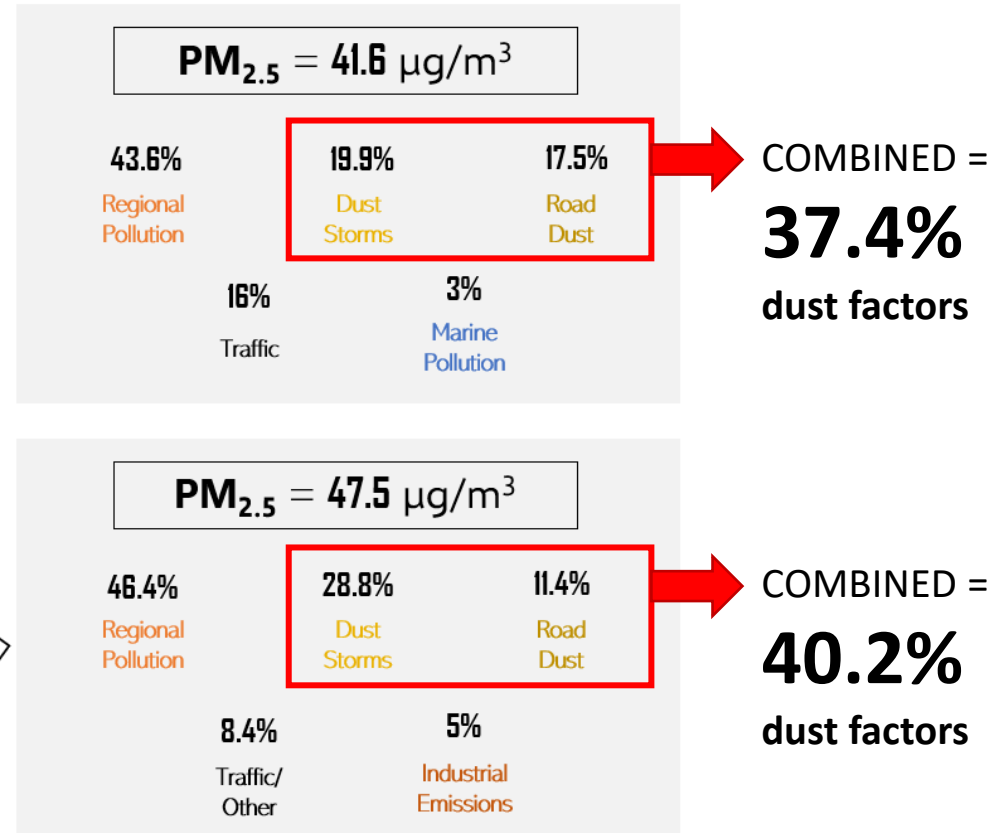
Change in risk for a respiratory disease hospitalization per 1 $\mu\text{g}/\text{m}^3$ increase in the total and source-specific ambient PM_{2.5} concentrations, over 0-5-day cumulative distributed lags, for the total population in Kuwait.

Exposure variable	Change in risk	95% CI
PM _{2.5}	0.16% 	(0.05, 0.27%)
Dust	0.16%	(0.04, 0.29%)
Regional	0.11%	(-0.11, 0.33%)
Traffic	-0.48%	(-1.61, 0.66%)
Other	-0.81%	(-2.66, 1.07%)

Composition of PM_{2.5} in Kuwait



Levels & Sources of Air Pollution in Kuwait

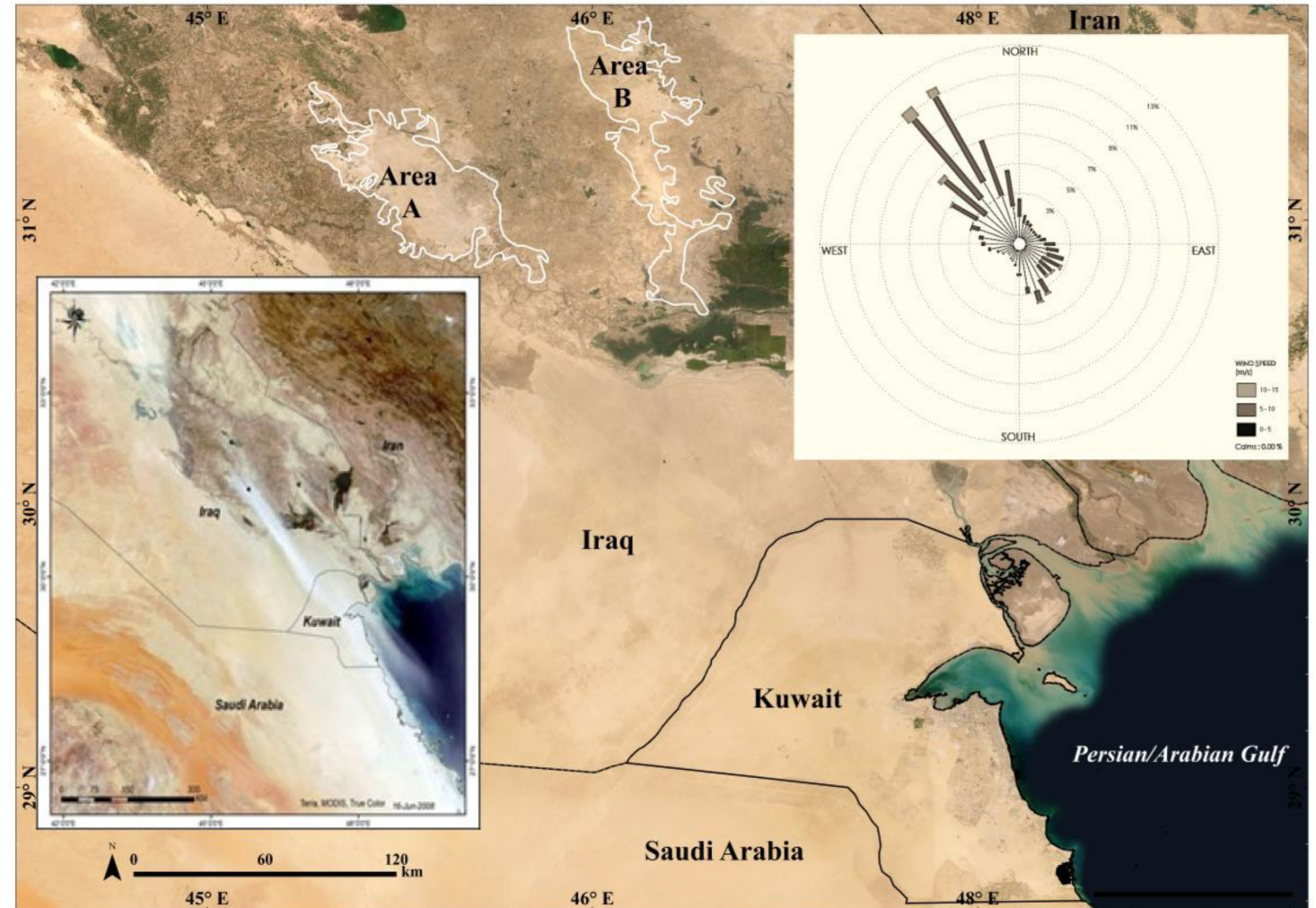


- Majority of pollution comes from **regional** oil operations + dust
- **Kuwait cannot eliminate all the air pollution alone**
- Anthropogenic pollution comes from Iraq, Iran, and Saudi Arabia (+ from within Kuwait)

Dust Sources from Hotspots in Iraq



Image by NASA MODIS Rapid Response team
[Iraq Dust Storms](#)



Al-Dousari et al. 2022; Al-Hemoud et al. 2024

Toxic Flares: BBC Commissioned Study

- Rumaila oil field (Iraq) is one of the world's largest flaring sources
- Some pollutants from Iraqi flaring sites (**PM_{2.5}**, **NO₂**, **benzo(a)pyrene**) reach northern Kuwait at concentrations well above European safety levels.



Source: Google Earth, Google GB, Landsat / Copernicus, Data SIO

BBC



How hidden oil pollution puts millions at risk in the Gulf - BBC World Service Documentaries

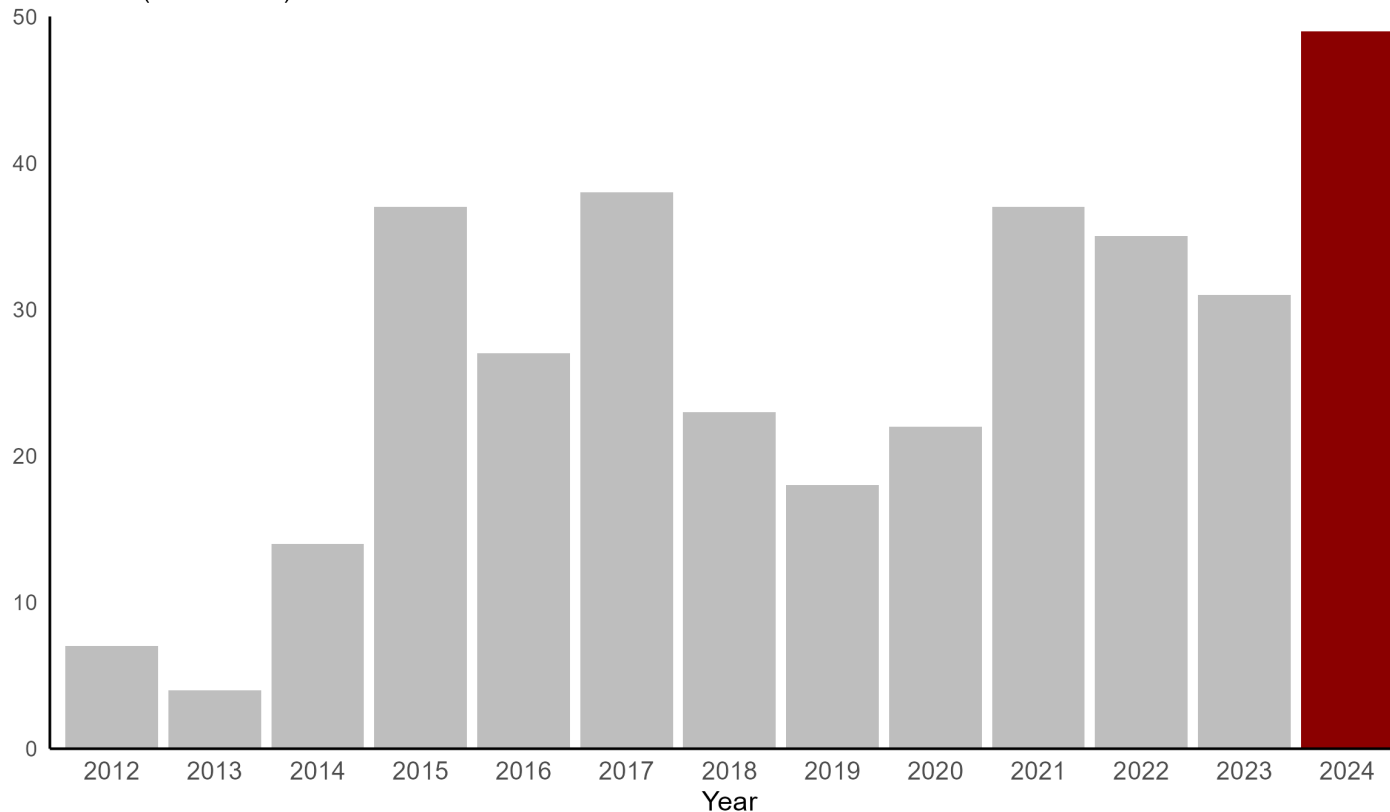
69K views • 2 months ago

BBC World Service

A BBC Arabic investigation has found that harmful air pollution from big companies including BP and ADNOC is spreading far ...

HEAT IN KUWAIT

Number of Classified 'Heat Danger' Days per Year
Kuwait (2012-2024)

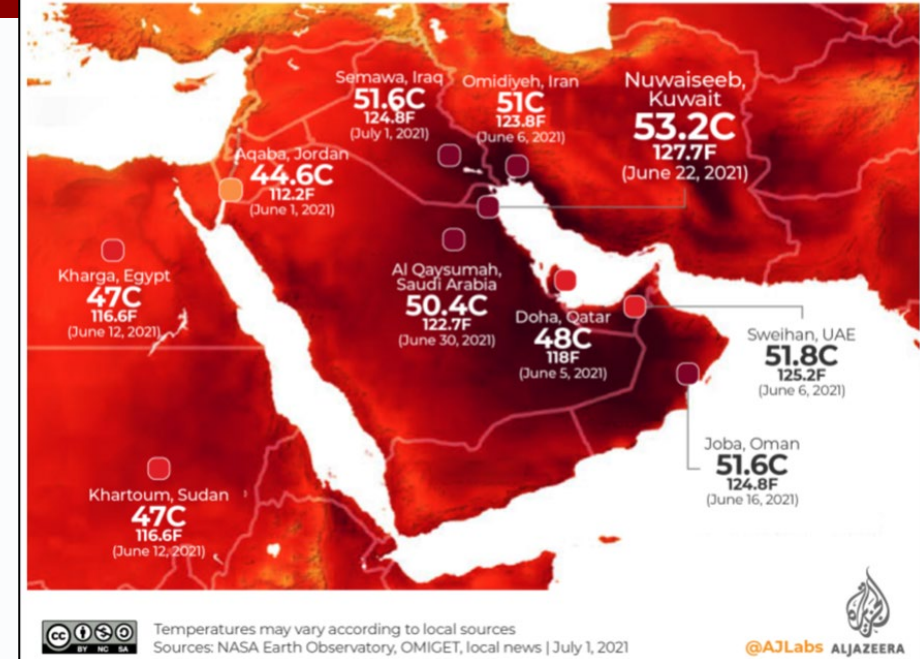


Source: Kuwait Meteorological Service

WEATHER

53.2C in Kuwait - the highest in 2021

On June 22, the Kuwaiti city of Nuwaiseeb recorded the **highest temperature in the world so far this year**. Several other countries in the Middle East recorded temperatures higher than 50C (112F).



MENU GULF NEWS KUWAIT

Kuwait registers highest temperature on earth for 2021

Kuwait registers highest temperature on earth for 2021

Nawasib city recorded 53.2 degrees Celsius, hottest temperature worldwide

Published: June 26, 2021 15:55
Tawfiq Nasrallah, Senior News Editor



Heat & Heart Disease in Kuwait

Analysis of DEATH CERTIFICATES Kuwait (2010-2016)

INTERNATIONAL FORM OF MEDICAL CERTIFICATE OF CAUSE OF DEATH

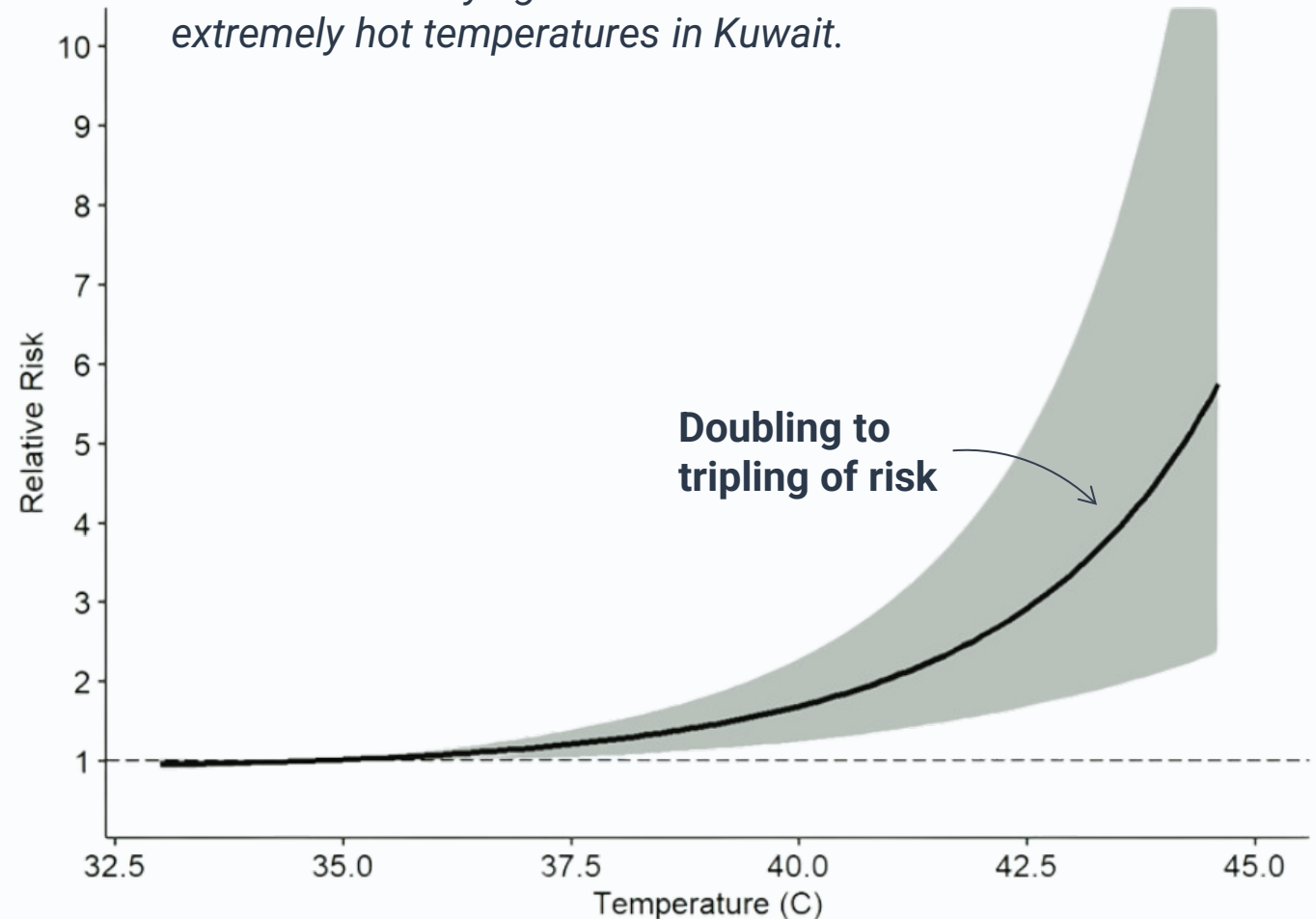
Cause of death		Approximate interval between onset and death
I Disease or condition directly leading to death*	(a)	
	due to (or as a consequence of)	
Antecedent causes Morbid conditions, if any, giving rise to the above cause, stating the underlying condition last	(b)	
	due to (or as a consequence of)	
	(c)	
	due to (or as a consequence of)	
	(d)	
II Other significant conditions contributing to the death, but not related to the disease or condition causing it		
		

*This does not mean the mode of dying, e.g. heart failure, respiratory failure. It means the disease, injury, or complication that caused death.



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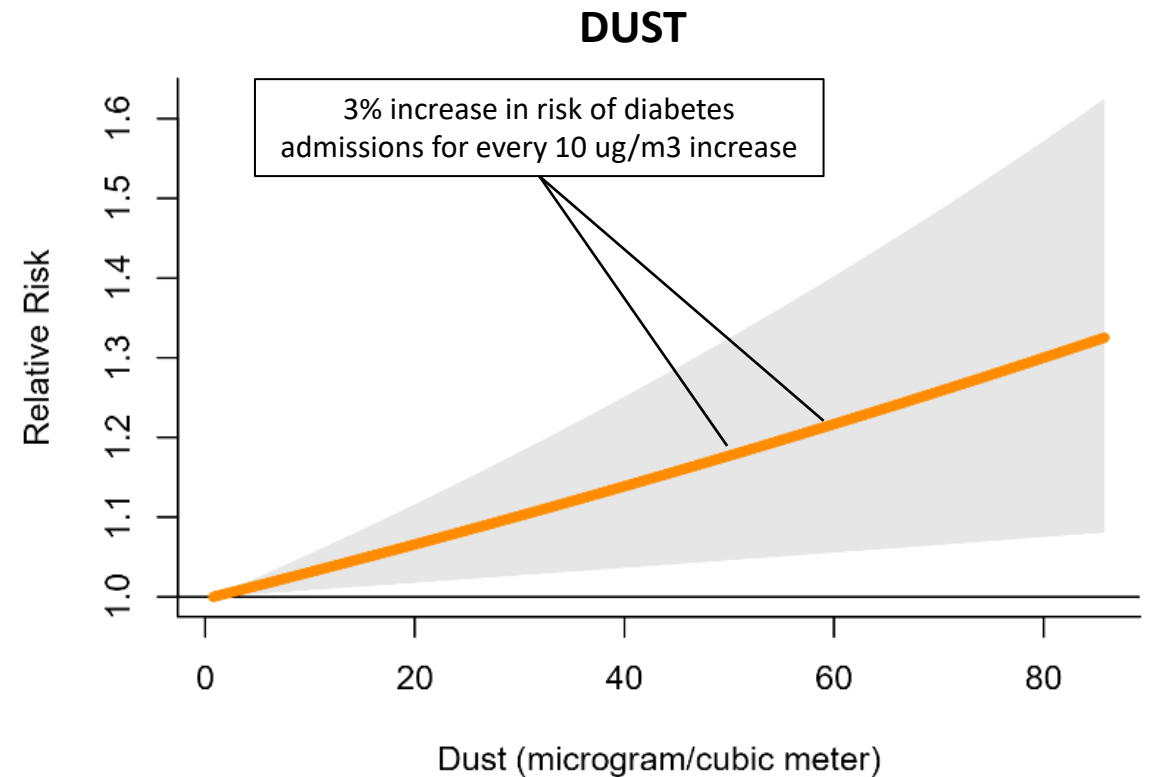
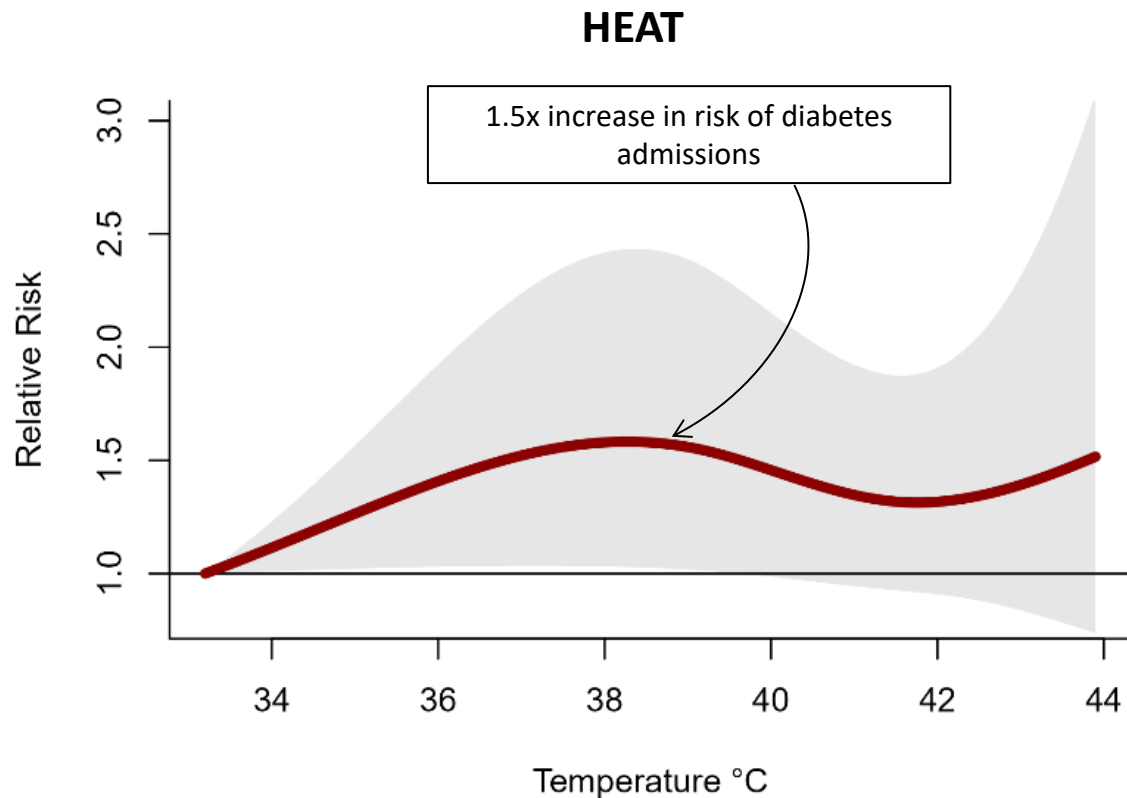
Relative risk of dying from heart disease and extremely hot temperatures in Kuwait.



Alahmad et al. (2020) *Circulation*

Diabetes Admissions

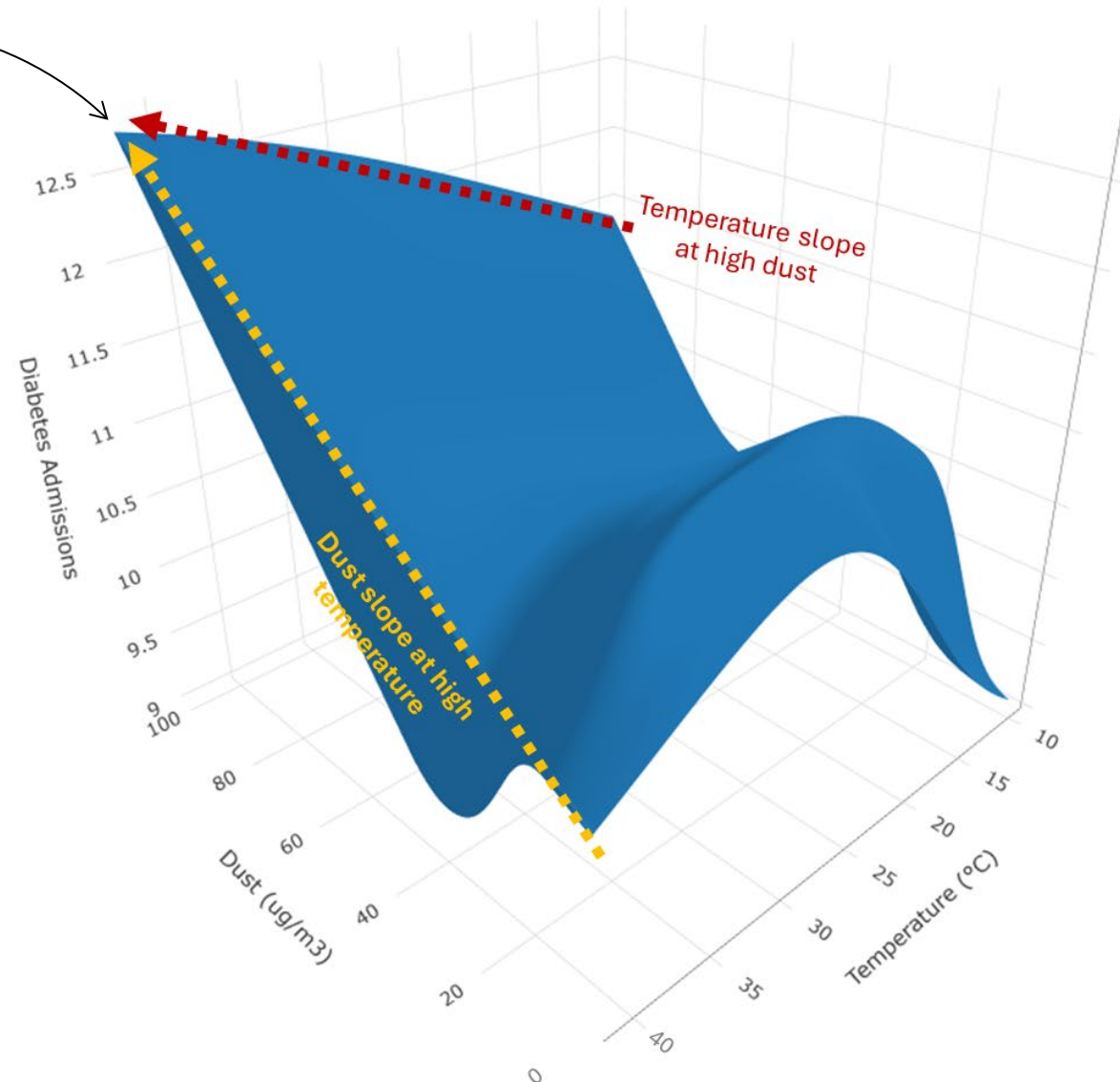
All 'non-planned' diabetes hospital admissions from 2010 to 2020 from all public hospitals in Kuwait **[EXCLUDING COVID]**



Combined Hot & Dusty

Temp = 41.6 °C
Dust = 85.8 ug/m³
Excess Diabetes Admissions =
12.6/day

This study provides empirical evidence that both extreme heat and dust storms **independently** and **jointly** increase hospitalization rates for diabetic patients in Kuwait



Open access

Original research

BMJ Open
Diabetes
Research
& Care

Combined impact of heat and dust on diabetes hospitalization in Kuwait

Barrak Alahmad^{1,2}, Hamad Ali^{2,3}, Yazan Alwadi¹, Ali Al-Hemoud⁴,
Petros Koutrakis¹, Fahd Al-Mulla²

Climate Change in the Middle East

Climatic Change (2016) 137:245–260
DOI 10.1007/s10584-016-1665-6



Strongly increasing heat extremes in the Middle East and North Africa (MENA) in the 21st century

J. Lelieveld^{1,2} · Y. Proestos² · P. Hadjinicolaou² ·
M. Tanarhte¹ · E. Tyrllis² · G. Zittis²

“ [Heat in MENA] will have important consequences for human health and society”



ELSEVIER

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint



Escalating heat-stress mortality risk due to global warming in the Middle East and North Africa (MENA)

Ali Ahmadalipour^{*}, Hamid Moradkhani



“Mortality risk will increase in distant future to 8–20 times higher than the historical period”

nature
climate change

LETTERS

PUBLISHED ONLINE: 26 OCTOBER 2015 | DOI: 10.1038/NCLIMATE2833

Future temperature in southwest Asia projected to exceed a threshold for human adaptability

Jeremy S. Pal^{1,2} and Elfatih A. B. Eltahir^{2*}

“... climate change [in the Arabian Gulf] is likely to severely impact human habitability in the future”

ENVIRONMENTAL RESEARCH
LETTERS

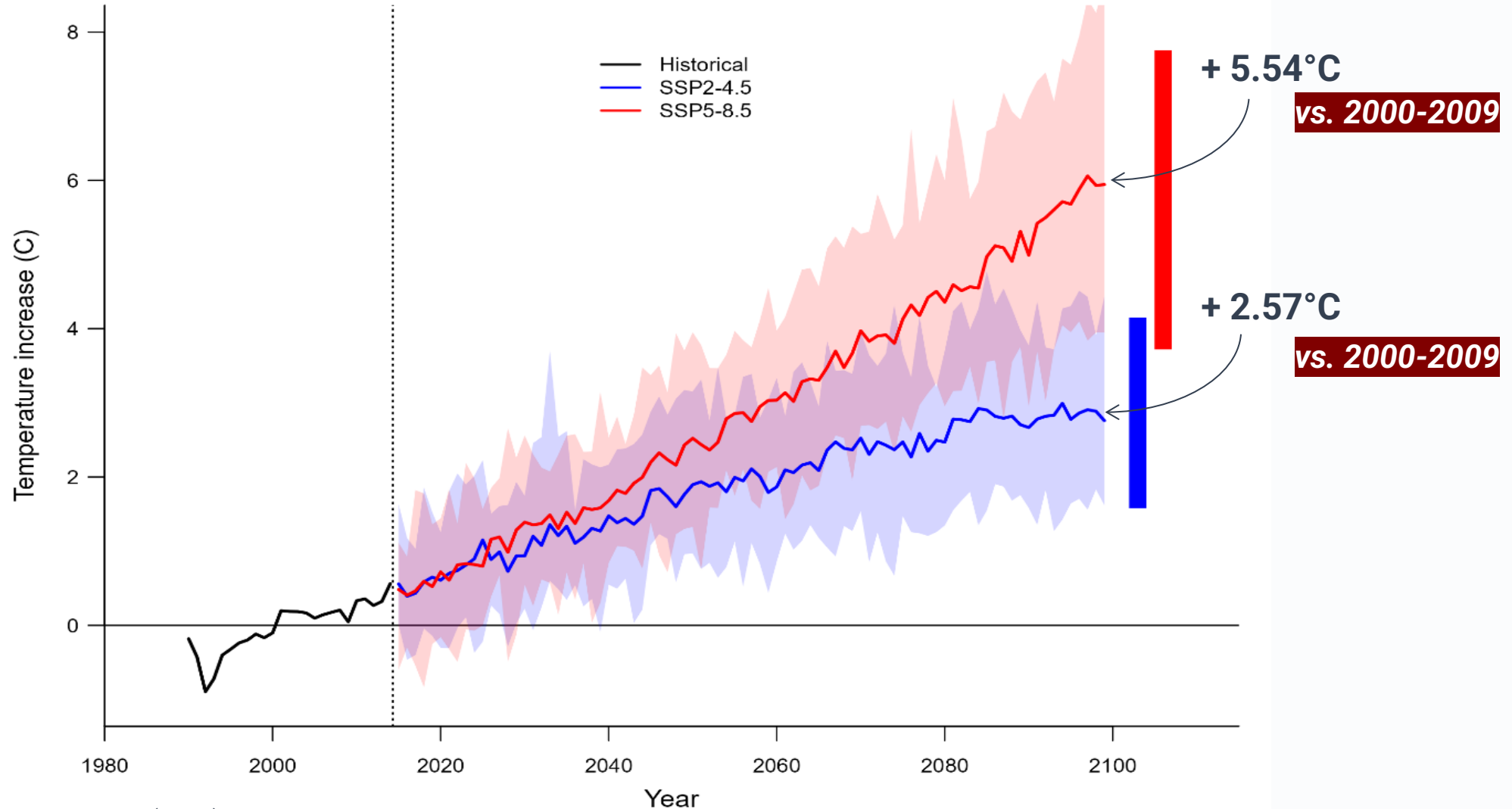
LETTER

Present and future land surface and wet bulb temperatures in the Arabian Peninsula

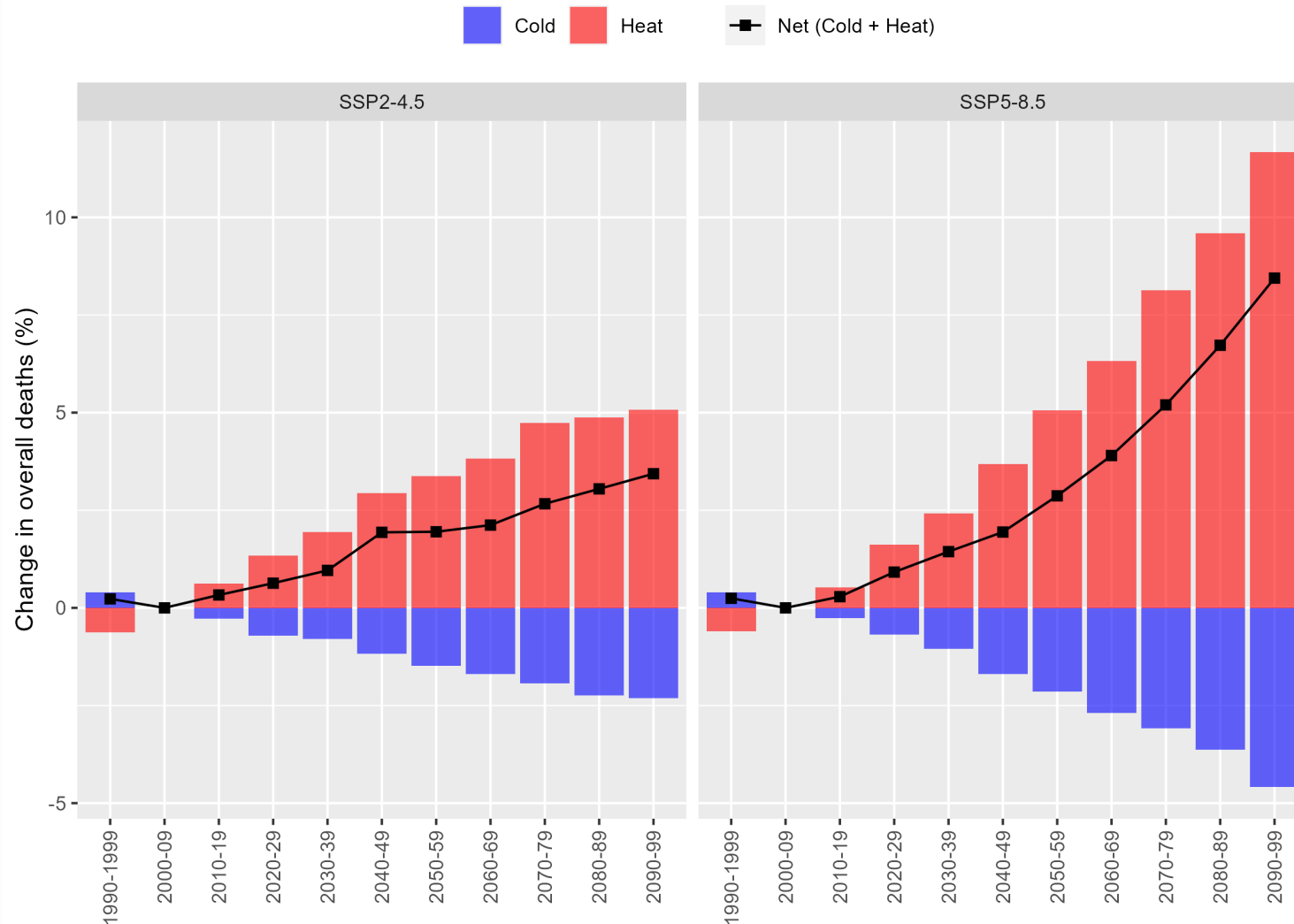
S Safieddine^{1,*}, C Clerbaux^{1,2}, L Clarisse², S Whitburn² and E A B Eltahir³

“... [climate change is] posing significant risks on human survivability in the [Arabian] Peninsula ”

Kuwait Climate Projections – Temperatures



Kuwait Climate Projections – Deaths



This could translate into:
14.6 of every 100 deaths in Kuwait may be attributable to heat from climate change by 2099

Moving Forward

AWARDED



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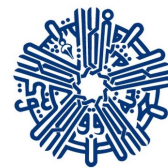
**Human health exposure
assessment and reduction
of air pollutants in Kuwait**

**3-year \$5M
(2024-2027)**

*Set air quality
standards, build
capacity, and
transfer technology
in exposure
assessment*

AWARDED

UN HABITAT
FOR A BETTER URBAN FUTURE



الصندوق الكويتي للتغذية
Kuwait Fund

**Combatting sand and dust
storms in Iraq and Kuwait**

**4-year \$13M
(2023-2027)**

*Restore ecosystems,
Improve resilience in
the source areas of
sand and dust
storms in Iraq &
Kuwait*

Proposal Stage...



**Kuwait Center of Excellence
for Environmental &
Occupational Health**

مركز التميز في الصحة البيئية
والصحة المهنية

**4-year \$1M
(2026-2029)**

*Create a self-sustained
leading regional center
for research and training
for a resilient workforce*

Environmental Health in Kuwait

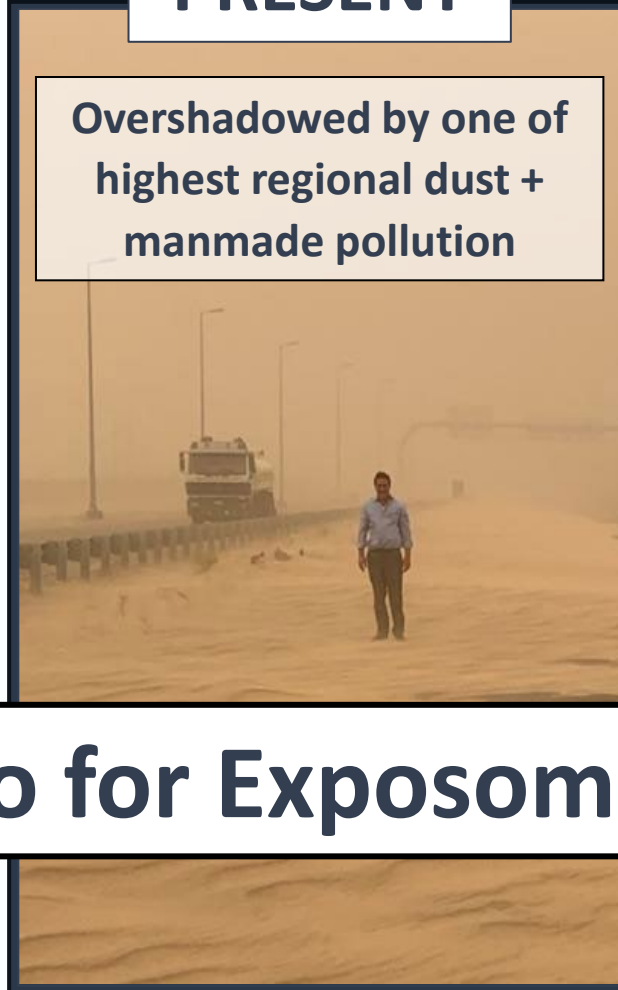
PAST

Overburdened by one of the world's worst environmental disasters



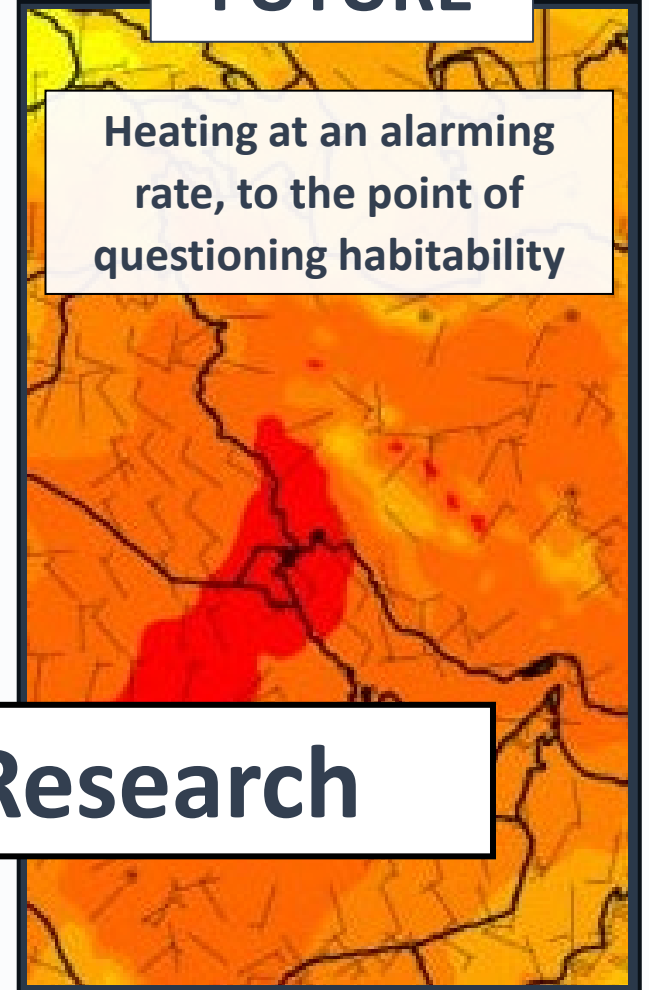
PRESENT

Overshadowed by one of the highest regional dust + manmade pollution



FUTURE

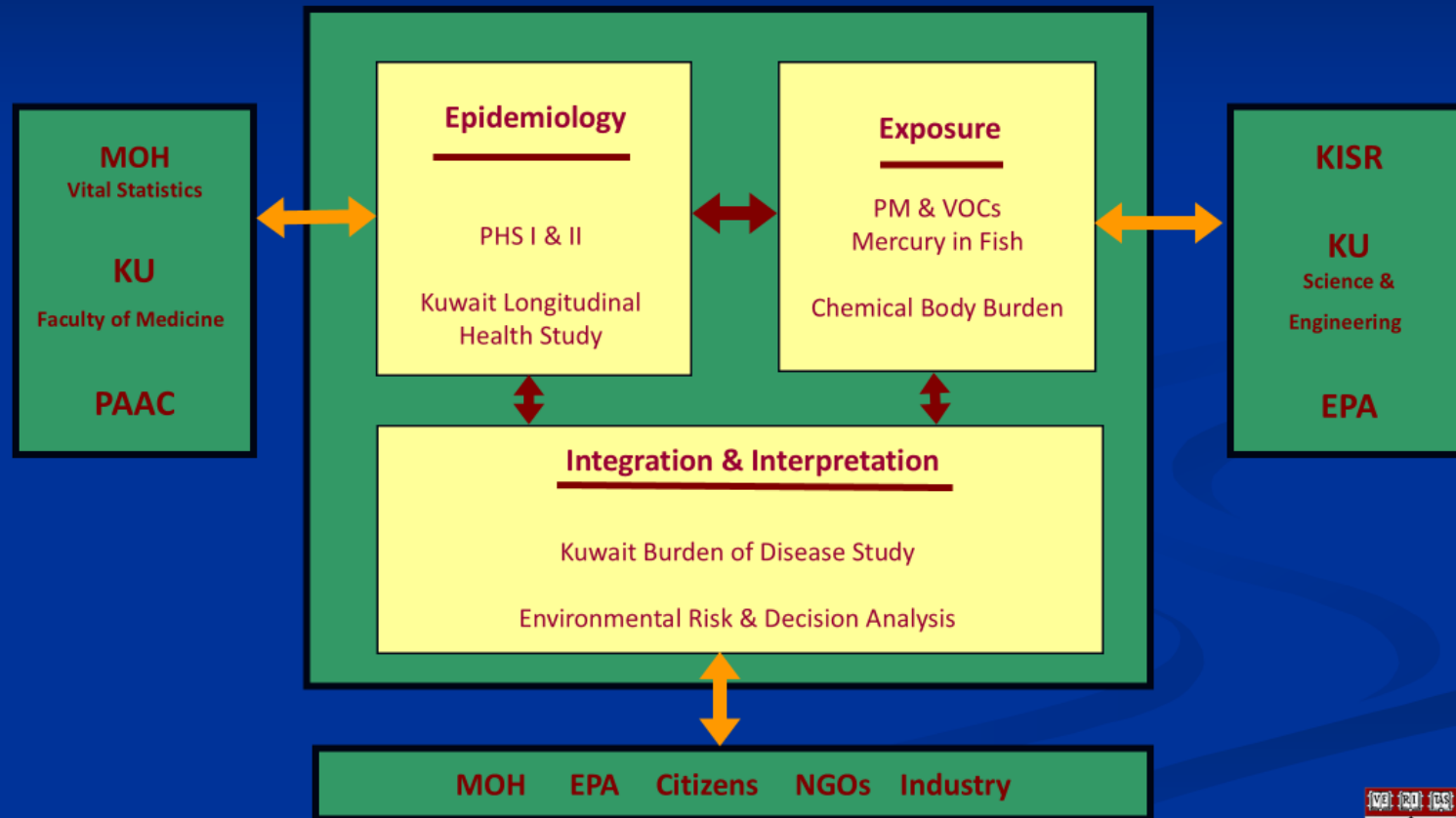
Heating at an alarming rate, to the point of questioning habitability



Ground Zero for Exposomics Research

2008 unfunded proposal

Kuwait National Center for Environment and Health



2025 Updated Vision

nature reviews genetics

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[nature](#) > [nature reviews genetics](#) > [comment](#) > article

Comment | Published: 31 July 2025

Integrating the genome and exposome for precision health in Kuwait

[Hamad Ali](#) , [Barrak Alahmad](#), [Faisal H. Al-Refaei](#), [Ahmad Abou Tayoun](#), [Hilal A. Lashuel](#), [Salman Al Sabah](#)
& [Fahd Al-Mulla](#)

[Nature Reviews Genetics](#) **26**, 735–736 (2025) | [Cite this article](#)

Acknowledgements

Harvard-Kuwait Study 1.0



John Evans



Jaafar Behbehani

Harvard-Kuwait Study 2.0



Petros Koutrakis



Walid Bouhamra

Harvard-Kuwait Study 3.0



Barrak Alahmad



Ali Al-Hemoud

- Douglas Dockery
- Abdulrahman Al-Muhailan
- David Mage
- Louise Hanson

- Martha Fay
- Mohammed Alseidan
- Kadhem Behbehani
- Mohammed Alolayan

... and many other Harvard-Kuwait collaborators

GRANTING INSTITUTIONS



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#PR19-13-NH-03



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Veterans Affairs
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