PONTIFICIA
UNIVERSIDAD
CATÓLICA
DE CHILE

Impactos de la temperatura en la salud de las personas

Luis Abdón Cifuentes

Departamento de Ingenieria Industrial y de Sistemas, PUC

Centro de Cambio Global UC

Presentación al Consejo del CLG

16 Enero 2025

IDF soldier collapses, dies during training amid heat wave

20-year-old Hillel Nehemiah Ofan declared dead at scene in forest near Elad; head of Ground Forces halts all exercises

By EMANUEL FABIAN FOLLOW
14 August 2023, 12:46 pm | Updated at 2:12 pm

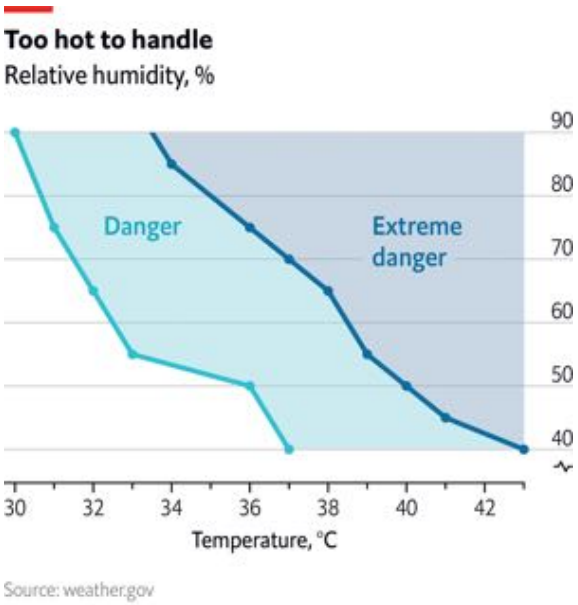
An undated photo of IDF soldier Hillel Nehemiah Ofan, who died August 14, 2023, during training near the central city of Elad. (Israel Defense Forces)

A soldier collapsed and died on Monday morning during a training exercise in a forest near the central city of Elad, the military said.

The Israel Defense Forces said it was investigating the cause of death, though first responders indicated the soldier was apparently suffering from

¿Cuál es la máxima temperatura soportable por el ser humano?

La combinación de Temperatura (seca) y Humedad relativa del aire, que se expresa como la temperatura del bulbo húmedo (o temperatura húmeda del aire)



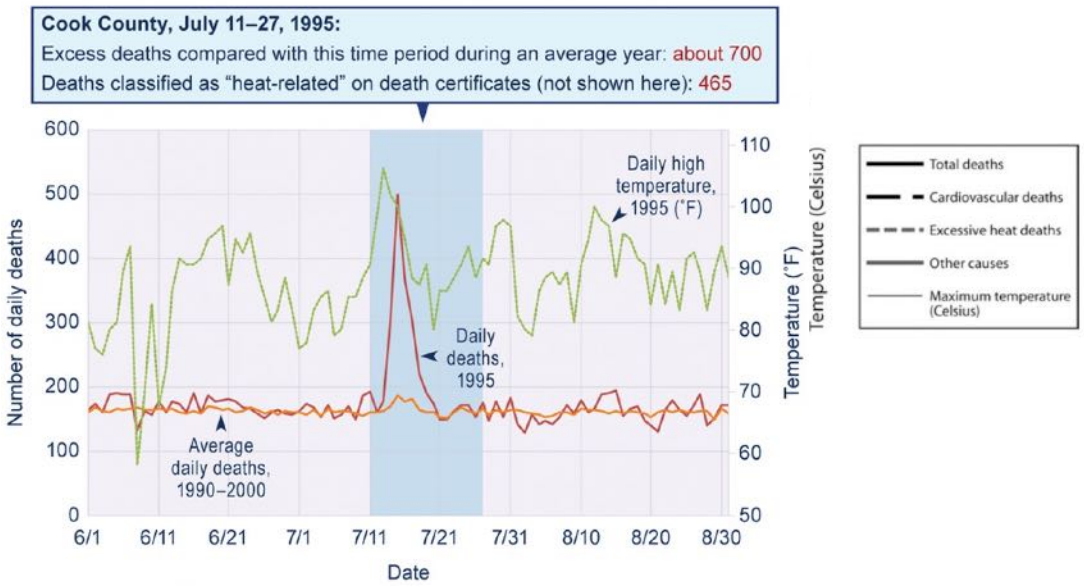
https://www.economist.com/the-economist-explains/2022/05/13/the-increasing-frequency-of-fatal-wet-bulb-temperatures

Death toll tops 60 across U.S. as arctic blast leaves dangerous icy conditions

The Mississippi Emergency Management Agency on Saturday announced two more deaths, which occurred in an incident on a highway in rural Leflore County, north of Jackson.

- https://www.nbcnews.com/news/weather/death-toll-tops-60-arctic-blast-us-leaves-c

Ola de Calor Chicago: 22 junio a 10 agosto 1995



- Kaiser, R., A. Le Tertre, et al. (2007). "The effect of the 1995 heat wave in Chicago on all-cause and cause-specific mortality." Am J Public Health **97 Suppl 1: S158-62.**

Ola de Calor en Francia, Agosto 2003
Mortalidad en exceso con respecto a promedio 1999-2002 en 13 ciudades

142% de muertes en exceso en 2003 con respect a promedio 1999-202

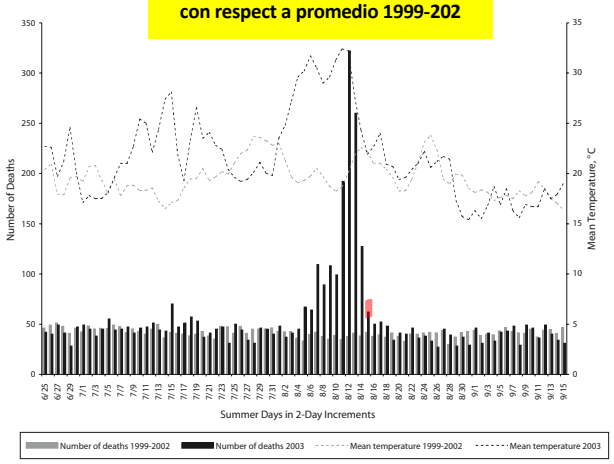


TABLE 1—Excess Mortality in 13 French Cities and in Hospitals Between August 1 and August 19, 2003, Compared With the Same Period in 1999–2002 for the City Deaths and in 2002 for the In-Hospital Deaths[a]

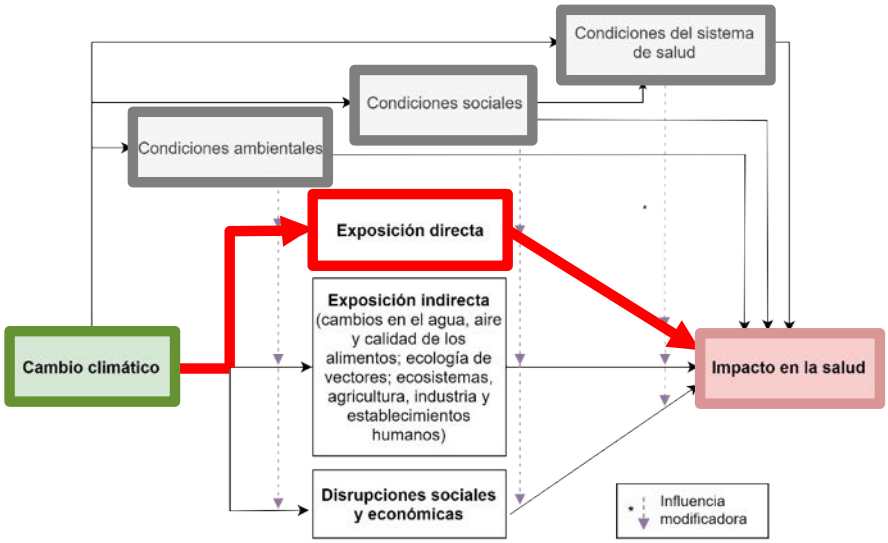
City	2003 No. of City Deaths	Excess Mortality, %	2003 No. of In-Hospital Deaths	Excess Mortality, %
Bordeaux	318	43	228	53
Dijon	168	93	117	121
Grenoble	148	28	108	24
Le Mans	204	82	171	116
Lille	200	4	103	18
Lyon	447	80	300	95
Marseille	571	25	163	23
Nice	341	53	193	65
Paris	1854	142	665	138
Poitiers	184	79	151	72
Rennes	156	36	95	38
Strasbourg	253	51	157	33
Toulouse	315	36	140	49

[a]City deaths do not include all the in-hospital deaths. Only patients who died in the university hospitals located in the city (not in the suburbs) were included in the 2 sources.

- Vandentorren, S., Suzan, F., Medina, S., Pascal, M., Maulpoix, A., Cohen, J. C., & Ledrans, M. (2004). Mortality in 13 French cities during the August 2003 heat wave. *American Journal of Public Health*, *94*(9), 1518–1520. https://doi.org/10.2105/AJPH.94.9.1518

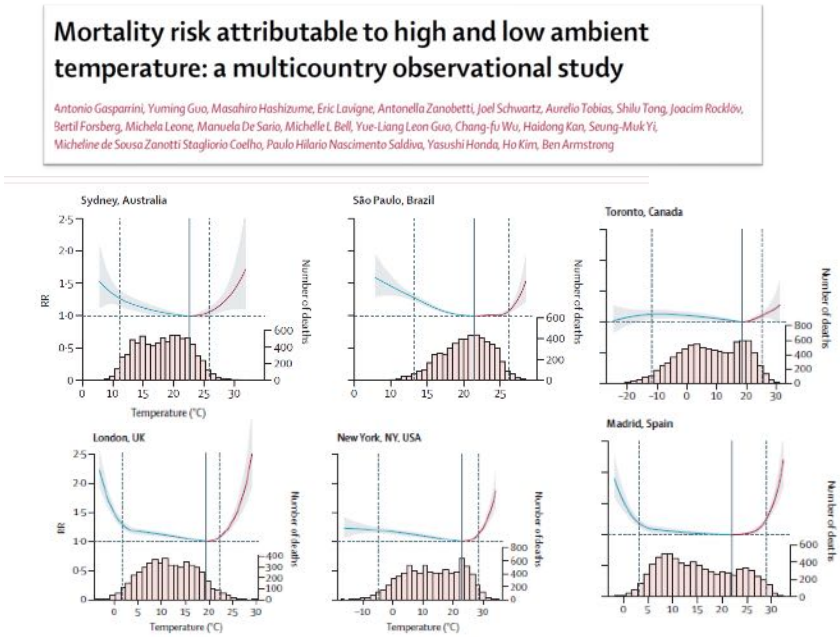
Aunque el ser humano habita en todos los climas, el *cambio climático* afecta su salud

El cambio climático afecta a la salud por muchas vías



Fuente: Traducida de (IPCC, 2007)

El riesgo depende de la temperatura base de la ciudad



Gasparrini, A., et al (2015). Mortality risk attributable to high and low ambient temperature: a multicountry observational study. Lancet, 386, 369–375.

Efecto de la Temperatura ambiental en la Mortalidad prematura en 3 ciudades de Latinoamérica (1998-2002)

Vulnerability to heat-related mortality in Latin America: a case-crossover study in São Paulo, Brazil, Santiago, Chile and Mexico City, Mexico

Michelle L Bell,[1]* Marie S O'Neill,[2] Nalini Ranjit,[2] Victor H Borja-Aburto,[3] Luis A Cifuentes[4] and Nelson C Gouveia[5]

Accepted 29 April 2008

Background Factors affecting vulnerability to heat-related mortality are not well understood. Identifying susceptible populations is of particular importance given anticipated rising temperatures from climatic change.

Methods We investigated heat-related mortality for three Latin American cities (Mexico City, Mexico; São Paulo, Brazil; Santiago, Chile) using a case-crossover approach for 734 291 deaths from 1998 to 2002. We considered lagged exposures, confounding by air pollution, cause of death and susceptibilities by educational attainment, age and sex.

Results Same and previous day apparent temperature were most strongly associated with mortality risk. Effect estimates remained positive though lowered after adjustment for ozone or PM_{10}. Susceptibility increased with age in all cities. The increase in mortality risk for those ≥65 comparing the 95th and 75th percentiles of same-day apparent temperature was 2.69% (95% CI: −2.06 to 7.88%) for Santiago, 6.51% (95% CI: 3.57–9.52%) for São Paulo and 3.22% (95% CI: 0.93–5.57%) for Mexico City. Patterns of vulnerability by education and sex differed across communities. Effect estimates were higher for women than men in Mexico City, and higher for men elsewhere, although results by sex were not appreciably different for any city. In São Paulo, those with less education were more susceptible, whereas no distinct patterns by education were observed in the other cities.

Conclusions Elevated temperatures are associated with mortality risk in these Latin American cities, with the strongest associations in São Paulo, the hottest city. The elderly are an important population for targeted prevention measures, but vulnerability by sex and education differed by city.

La forma de la relación temperatura-mortalidad es diferente para cada ciudad, porque tienen diferente clima

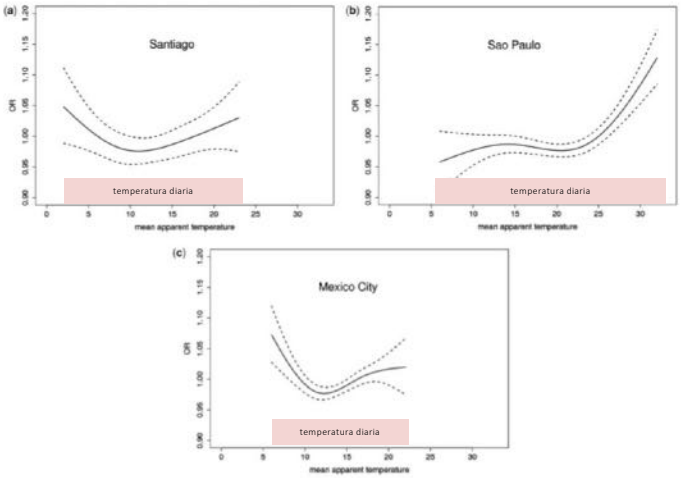


Figure 2 Exposure–response curves for mean apparent temperature and risk of mortality for: (**a**) Santiago; (**b**) São Paulo and (**c**) Mexico City. *Note*: The solid lines reflect the central estimate and the dashed lines the 95% CI. All models are adjusted for ozone at lag 0 for all cities and for PM_{10} at lag 1 for Santiago and lag 0 for Mexico City and São Paulo

Evidencia de Efectos en Chile (y el mundo)

1. **Mortalidad:** Series de tiempo y Case Time Series a nivel de comuna
2. **Hospitalizaciones:** Series de tiempo
3. **Urgencias**: Case Time Series a nivel de establecimiento
4. **Visitas Médicas:** Case Time Series a nivel de paciente
5. **Productividad:** Case Time Series de licencias medicas a nivel de comuna de residencia

El estudio

Objetivo

☐ Determinar la asociación de las visitas al médico (consultas médicas) con variables ambientales (contaminación atmosférica y temperatura ambiente) considerando las características de cada persona (paciente)

Datos

- Registro de atenciones médicas del Sistema BUPA para pacientes que se atendieron por causa cardiovascular al menos 1 vez durante el periodo 2012-2022.
- Para cada paciente se conoce: edad, sexo
- Para cada visita se registra: fecha, código de la causa, medicamentos recetados

Método:

☐ Series de tiempo por caso: relación estadística entre la fecha de la visita y las condiciones ambientales, considerando las características ***observables*** de cada paciente y también las ***no observables.***

Ventajas

☐ Mayor precisión: cada paciente actúa como su propio control

☐ La información de cada paciente individual permite estudiar el efecto de condiciones individuales (que se pierde o no está disponible cuando se usan datos agregados como el número diario de efectos

Datos

☐ Datos para casi 1.7 millones visitas médicas de 78 mil pacientes entre 2012 y 2022, que consultaron por alguna causa cardiovascular en 2019.

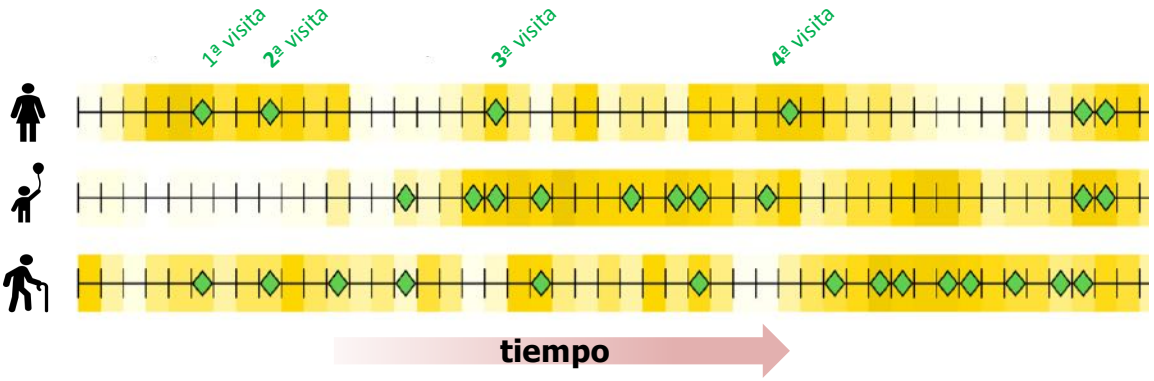
☐ 221 mil visitas por causas cardiovasculares de 68 mil pacientes únicos

Año	Pacientes únicos en el año	Visitas
2012	22,254	79,772
2013	26,300	95,537
2014	29,531	109,090
2015	32,541	123,216
2016	37,012	146,144
2017	40,337	158,230
2018	47,646	202,340
2019	**78,173**	**342,199**
2020	45,052	155,645
2021	38,805	117,442
2022	42,425	165,537
Total	**78,328**	**1,695,152**

Año	Pacientes únicos en el año	Visitas
2012	3,818	7,293
2013	4,982	9,536
2014	5,805	11,030
2015	7,041	13,109
2016	7,957	14,806
2017	9,386	17,483
2018	13,597	25,892
2019	**63,415**	**88,946**
2020	11,697	18,205
2021	1	1
2022	9,049	15,325
Total	**68,544**	**221,626**

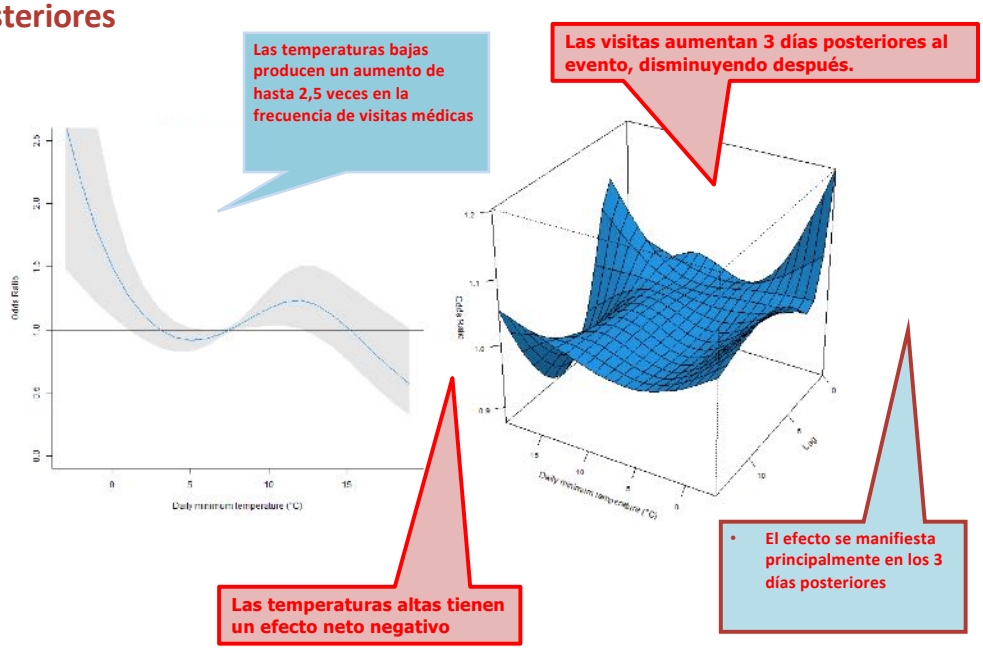
Series de Tiempo de Casos individuales (case time series)

- Relacionan los factores ambientales con la ocurrencia del efecto en cada paciente en particular
- Permite considerar las características de cada paciente (sexo, edad, estado de salud, comorbilidades, peso, etc.) que influyen en su vulnerabilidad.

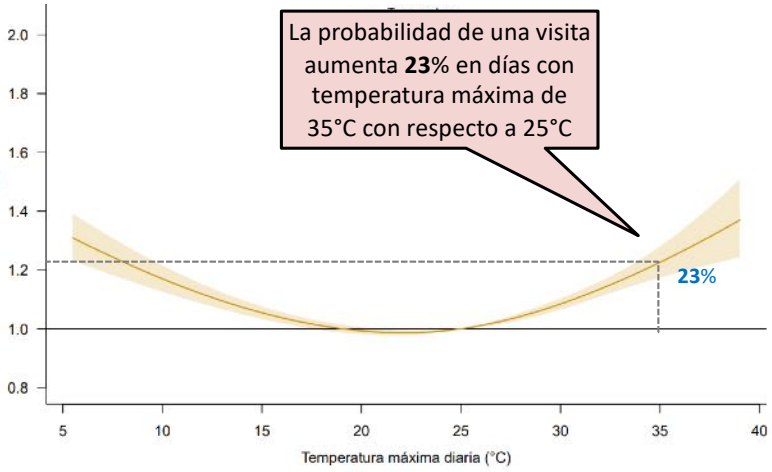


Fuente: **Gasparrini, A. (2021).** The Case Time Series Design. *Epidemiology*, *32*(6), 829–837.

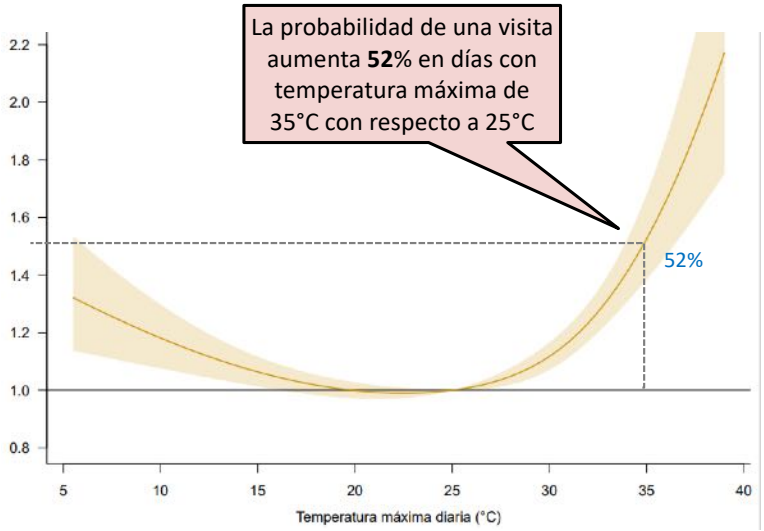
El método considera el efecto de la temperatura en el mismo día y en días posteriores



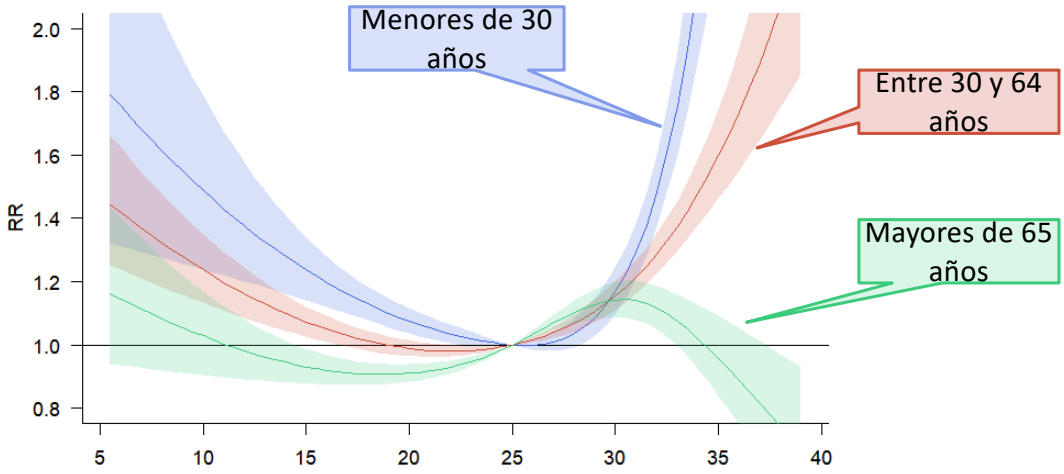
Riesgo relativo de visitas médicas asociado a temperatura diaria
Todas las causas



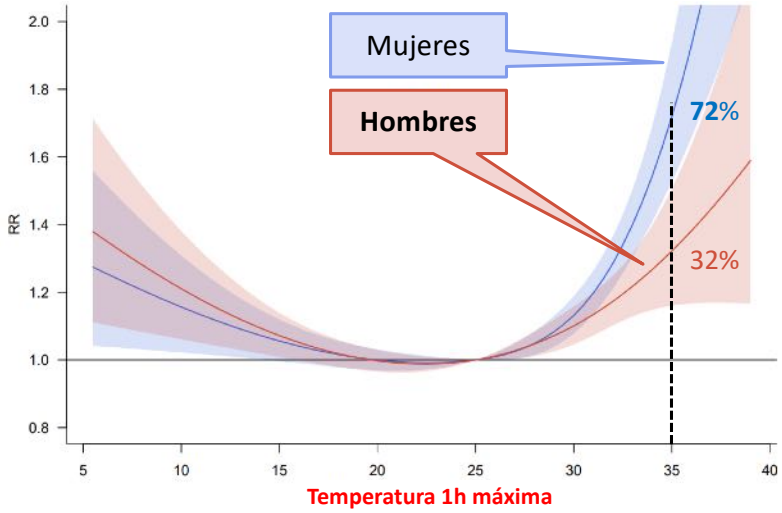
Riesgo relativo de visitas médicas asociadas a temperatura diaria
Causas del sistema circulatorio



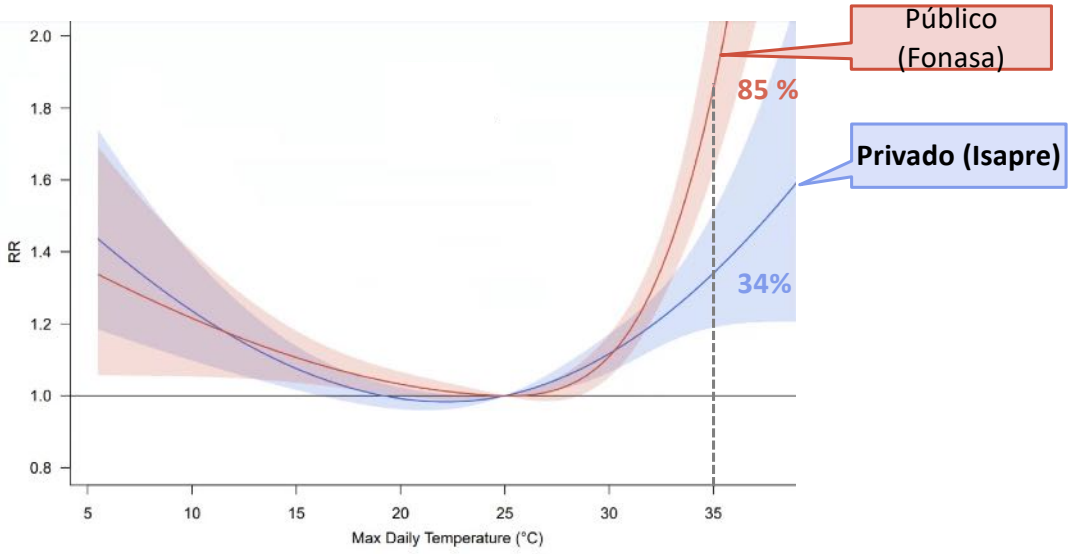
Riesgo relativo de visitas médicas asociadas a temperatura diaria
Causas del sistema circulatorio por Grupo Etario



Riesgo relativo de visitas médicas asociadas a temperatura diaria
Causas del sistema circulatorio por Sexo



Riesgo relativo de visitas médicas asociadas a temperatura diaria
Causas del sistema circulatorio por Sistema de Salud



Nuestros agradecimientos a:

BUPA:

- ☐ Hernán Salgado, Gerente de Sustentabilidad de BUPA
- ☐ Paulina Gómez, Directora Médica de Bupa Chile
- ☐ Al sistema de gestión de datos de BUPA por su buena disposición y por proporcionar los datos limpios y en el formato adecuado

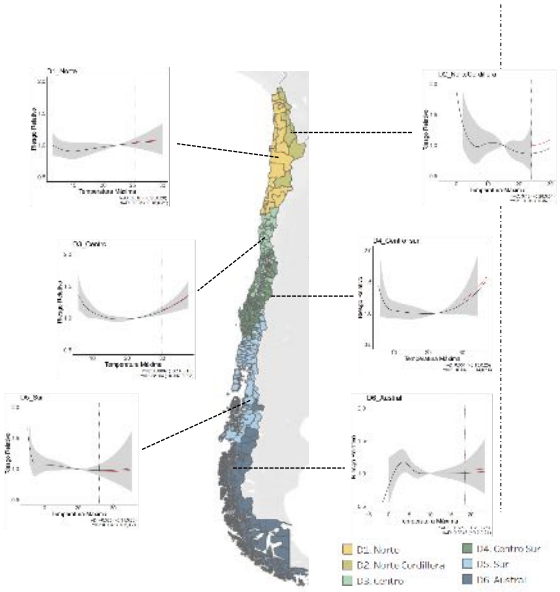
Equipo UC

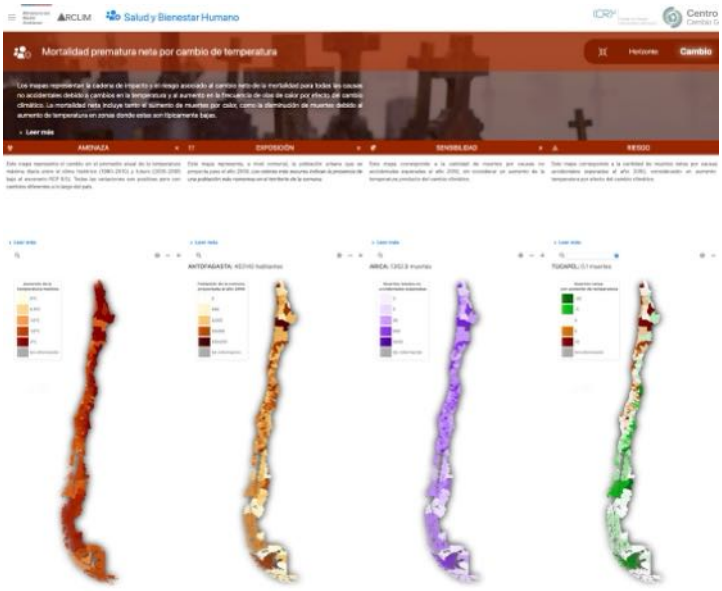
- ☐ Luis Abdón Cifuentes (Ingeniería Industrial UC, Centro de Cambio Global UC, Greenlab/DICTUC)
- ☐ Cristian Salas (Centro de Cambio Global UC)
- ☐ Alejandro Bañados (Centro de Cambio Global UC, Greenlab/DICTUC)
- ☐ Nicolás Valdés (Centro de Cambio Global UC, Greenlab/DICTUC)

Mortalidad

Atlas interactivo disponible en https://arclim.mma.gob.cl

Curvas Temperatura-Mortalidad para 6 regiones climáticas





Mortalidad prematura en exceso en 2050 con respecto a 1980-2010

(muertes esperadas: mediana e intervalo de confianza 95%)

Zona Climática	Estación cálida	Estación fría	Total Anual
D1. Norte	140 (-50 - 330)	0 (0 - 0)	140 (-50 - 330)
D2. Norte Cordillera	28 (-220 - 270)	-8 (-30 - 14)	20 (-250 - 290)
D3. Centro	950 (420 - 1470) **	-240 (-320 - -160)**	700 (260 - 1150)**
D4. Centro Sur	230 (-30 - 470) *	-130 (-320 - 50)	90 (-80 – 27-)
D5. Sur	90 (-7 - 190) *	-250 (-569 - 79)	-150 (-580 - 270)
D6. Austral	2 (-7 - 12)	-20 (-30 - -9) **	-17(-20 - -10)**
Total País	1430 (210 – 2 660) **	-650 (-1220 - -70)**	790 (-150 – 1 700)

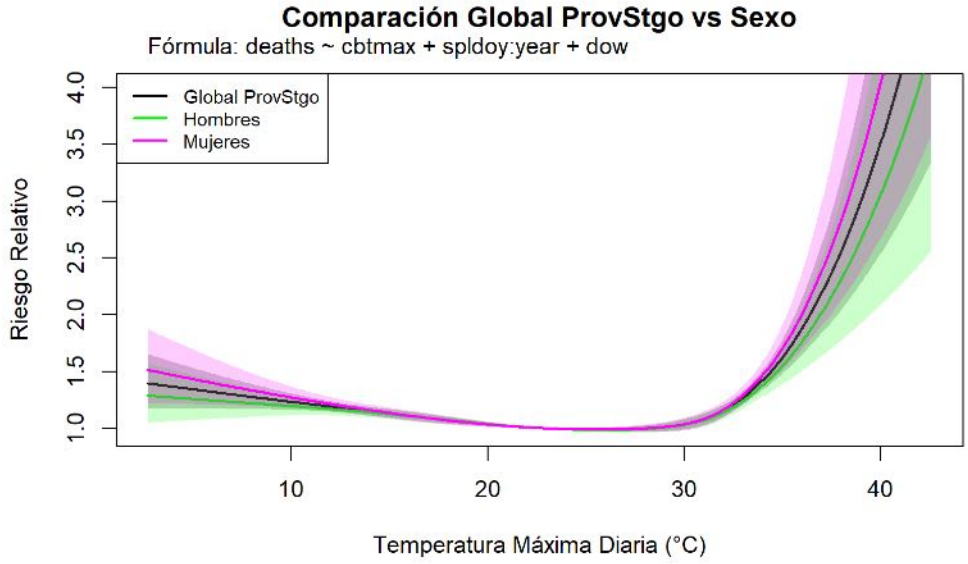
Notas:

Se usa definición Estricta de olas de calor: p.98 - 3+ días
Se presentan resultados de mediana e intervalo de confianza de 90%.
**** Significancia estadística de 90%**
*** Significancia estadística de 80%**

Proyecto de Carga de la Enfermedad debido a temperatura

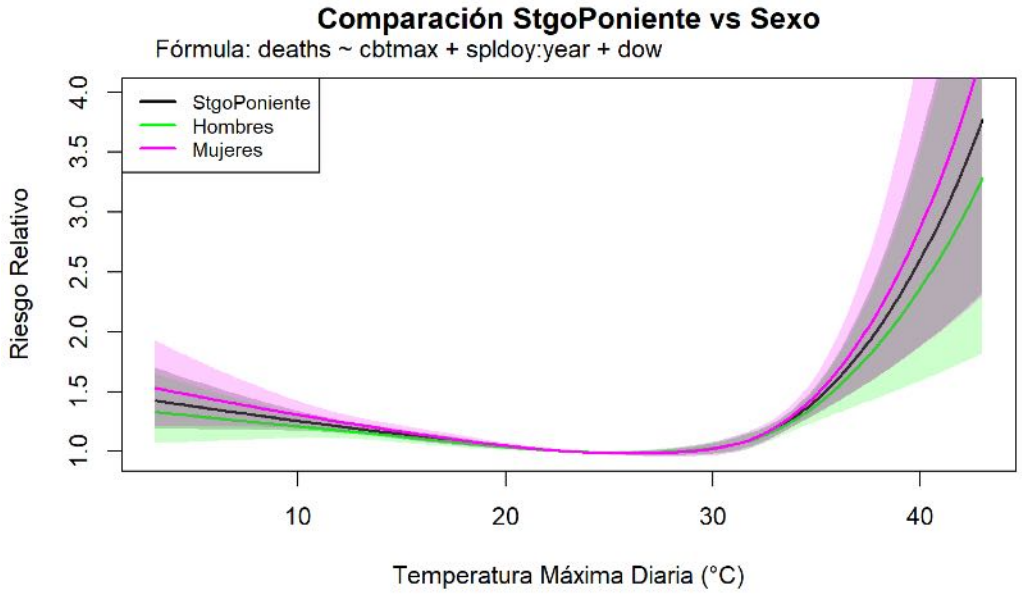
- En Conjunto con BUPA Chile
- Estimacion de la carga de la enfermedad: Mortalidad, visitas medicas por los cambios de temperatura

Proyecto de Carga de la Enfermedad debido a temperatura



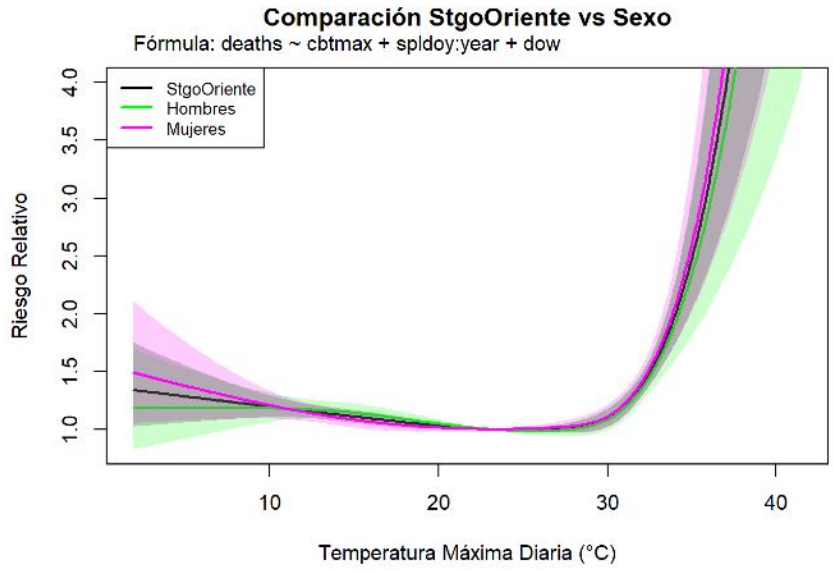
☐ Resultados preliminares – NO CITAR ni REPRODUCIR

Proyecto de Carga de la Enfermedad debido a temperatura



☐ Resultados preliminares – NO CITAR ni REPRODUCIR

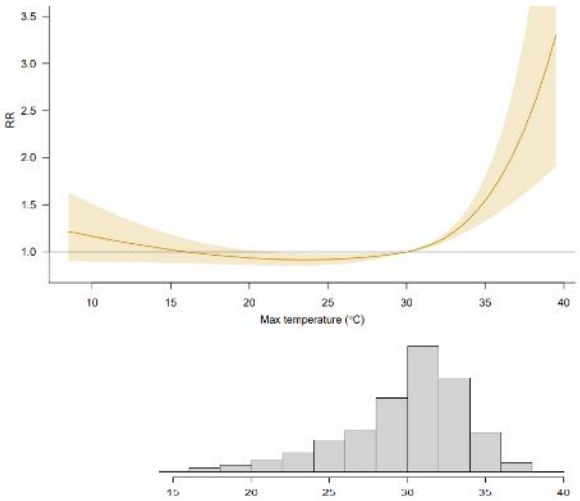
Proyecto de Carga de la Enfermedad debido a temperatura



- Resultados prelimina

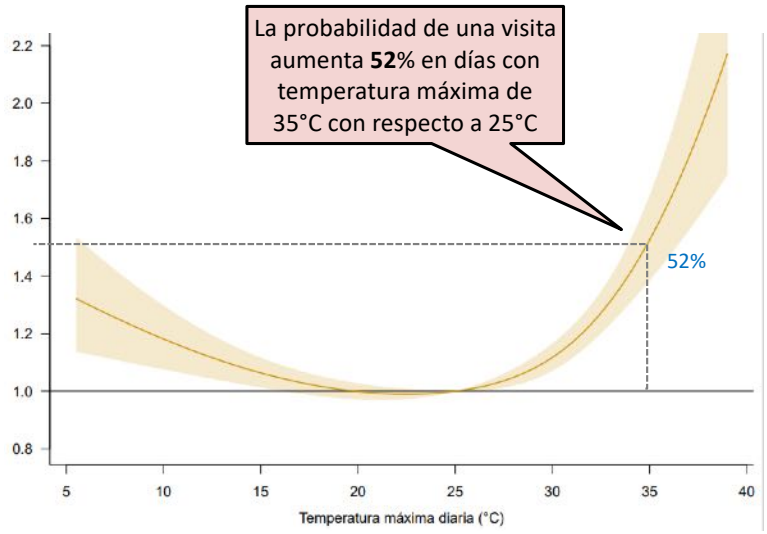
Visitas de Urgencia: Resultados preliminares

- Atenciones Urgencias por causas cardiovasculares, temporada cálida (octubre-marzo)
- Un día con temperatura máxima de **35°C** en Santiago, está asociado a un aumento de aproximadamente un **55%** en la mortalidad.
- En comparación a un día con una máxima de 30°C.
- Pero esto a sube a **151%** para **38°C**.



- Estudio en desarrollo (Final marzo 2024), financiado por BUPA
- Datos atenciones urgencias DEIS para RM, 2011-2020
- Se utiliza nuevo diseño de Case Time Series
- Se analiza a nivel de establecimiento de salud
- Temperaturas de una estimación grillada histórica (CR2Met)

Frecuencia de visitas médicas
Enfermedades del sistema circulatorio

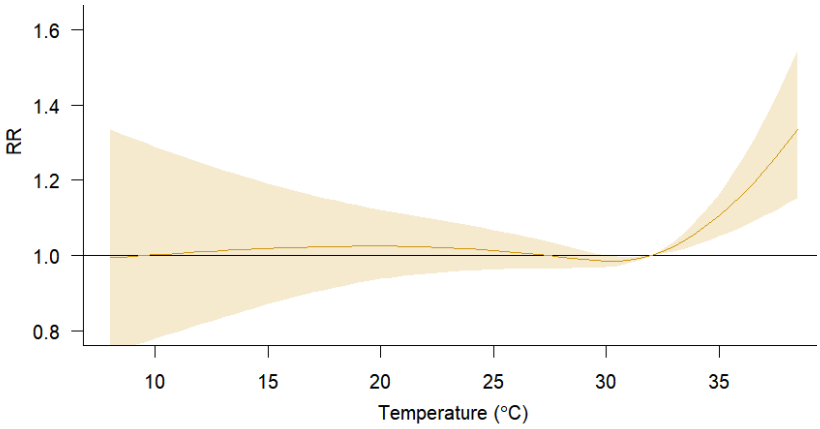


Fuente:

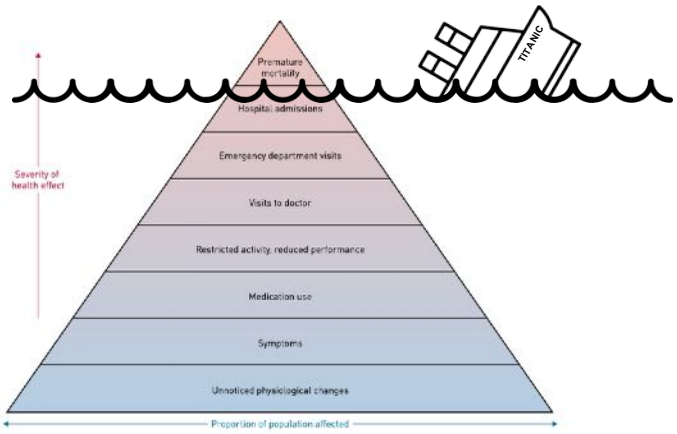
Licencias médicas: trastornos mentales y del comportamiento

Riesgo relativo de solicitud de licencias médica por trastornos mentales y del comportamiento asociado a temperatura máxima diaria con respecto a 32°C, para el verano.

- Durante el verano, un día con temperatura máxima de 35°C (código rojo) está asociado a un aumento de 13% en la solicitud de licencias médicas mentales, en comparación a un día de 32°C (sin código).
- Indicadores compuestos de estrés térmico (como WBGT) mostraron mejor predictibilidad.



La evidencia actual, centrada en mortalidad prematura, es sólo la punta del iceberg



- Slide gentileza del Dr. Aurelio Tobias

Ambio 2019, 48:350–362
https://doi.org/10.1007/s13280-018-1084-1

KUNGL. VETENSKAPS-AKADEMIEN

CrossMark

RESEARCH ARTICLE

Human–environmental drivers and impacts of the globally extreme 2017 Chilean fires

David M. J. S. Bowman, Andrés Moreira-Muñoz, Crystal A. Kolden, Roberto O. Chávez, Ariel A. Muñoz, Fernanda Salinas, Álvaro González-Reyes, Ronald Rocco, Francisco de la Barrera, Grant J. Williamson, Nicolás Borchers, Luis A. Cifuentes, John T. Abatzoglou, Fay H. Johnston

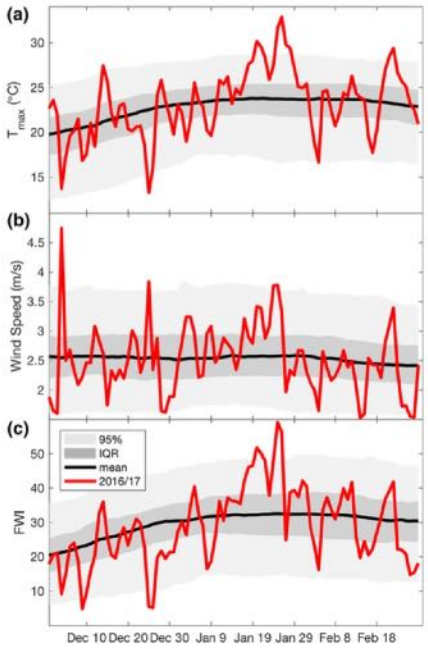


Fig. 4 Daily **a** maximum temperature, **b** mean wind speed, and **c** Fire Weather Index from December 1, 2016–February 28, 2017 averaged over central Chile. The light and dark gray depict 21-day moving averages of the interquartile range (IQR) and the middle 95% of the data for the period of record (1979–2017), while the bold black line shows the average daily data from 1981–2010

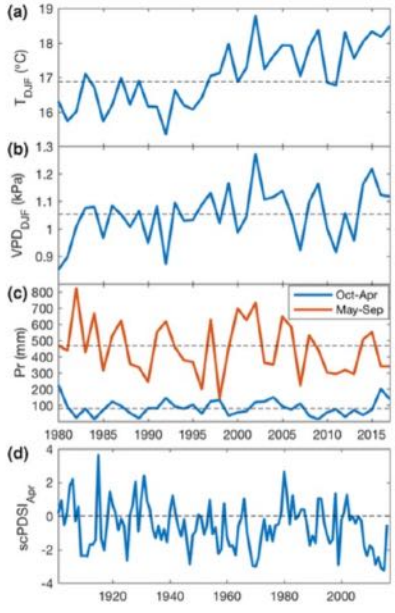


Fig. 5 Time series of **a** December–February mean temperature, **b** December–February vapor pressure deficit (VPD), **c** cumulative precipitation for the warm season (Oct–Apr) and cool season (May–Sep), and **d** April self-calibrated Palmer Drought Severity Index for central Chile. The horizontal dashed lines depict the 1981–2010 averages in (**a**–**c**)

Table 1 Pearson's correlation coefficients between the base-10 logarithm of fire season (Dec–Mar) burned area in central Chile and climate variables both concurrent to and antecedent to the fire season. Correlations were computed over a 32-year period from the fire season 1984/85 to 2015/16. Statistically significant correlations at $p < 0.05$ are shown in bold. All climate data were aggregated over land covering 32–38°S, 70–72.5°W

Variable	All fire	Plantation	Non-plantation
Mean temperature (Dec–Feb, DJF)	**0.32**	**0.45**	0.22
Precipitation (DJF)	− 0.09	− 0.03	− 0.16
Vapor pressure deficit (DJF)	**0.37**	**0.43**	**0.36**
Days where the Fire Weather Index > 95th percentile (DJF)	**0.39**	**0.47**	**0.36**
Self-calibrated Palmer Drought Severity Index (DJF)	− 0.26	− **0.34**	− 0.22
Precipitation (previous wet season, May–Sep)	− **0.31**	− **0.30**	− **0.30**
Precipitation (previous warm season, Oct–Apr, lag − 1)	**0.46**	**0.39**	**0.46**
Precipitation (previous wet season, May–Sep, lag − 1)	**0.41**	**0.41**	**0.35**

exposed to an average increase in $PM_{2.5}$ of 26.8 μg/m^3 above historical mean concentrations for a period of 16 days (Fig. 7). The calculated health impacts of the increased air pollution were (N, 95% Confidence interval): 76 (24–132) premature deaths 140 (0–343) respiratory hospital admissions and 69 (15–127) cardiovascular hospital admissions (Table S5).

DISCUSSION

Changing America

Shared Destiny. Shared Responsibility.

Sustainability > Climate Change

In major shift, experts say climate change finally being recognized as public health issue

"The burning of fossil fuels is killing us. Climate change is the single biggest health threat facing humanity."

By Shirin Ali | Nov. 22, 2021

Home | **Health at COP28**

- https://www.youtube.com/watch?v=U1wGwHD9GNA

Over 120 countries back COP28 UAE Climate and Health Declaration delivering breakthrough moment for health in climate talks

- The COP28 Presidency, in partnership with the World Health Organization and UAE Ministry of Health and Prevention, unveiled the 'COP28 UAE Declaration on Climate and Health' to place health at the heart of climate action and accelerate the development of climate-resilient, sustainable and equitable health systems.
- A set of new finance commitments on climate and health was announced to back up these political commitments, including a USD 300 million commitment by the Global Fund to prepare health systems, USD 100 million by the Rockefeller Foundation to scale up climate and health solutions, and an announcement by the UK Government of up to GBP 54 million. The Declaration is announced ahead of the first ever Health Day at a COP and joins a series of announcements made during the World Climate Action Summit to keep 1.5C within reach.
- Endorsed by 123 countries, the Declaration marks a world first in governments acknowledging the growing health impacts of climate change on communities and countries. It also acknowledges the large benefits to people's health from stronger climate action, including by reducing air pollution and lowering health care costs.
- For the first time, Health Ministers are attending the annual UN climate conference alongside their peers from Environment Ministries. This signals a shift in how climate policies are considered, with a stronger focus on the social implications of government decisions.
- The announcement comes as annual deaths from polluted air hit almost 9 million, heat-related illness and death on the rise, and as 189 million people are exposed to extreme weather-related events each year.

Dubai, 2 December 2023 :

Today the COP28 Presidency joined with the World Health Organization to announce a new 'COP28 UAE Declaration on Climate and Health' (the Declaration) to accelerate actions to protect people's health from growing climate impacts. The Declaration was announced at the World Climate Action Summit, where world leaders have gathered for the start of COP28.

- https://www.cop28.com/en/news/2023/12/Health-Declaration-delivering-breakthrough-moment-for-health-in-climate-talks

COP28UAE

Putting Health at the Heart of the Climate Agenda

Media Factsheet

Historic Focus on Climate Health Impacts

The 'Putting Health at the Center of Climate Agenda' session of the World Climate Action Summit on 2nd December, combined multiple transformative climate health announcements to drive down emissions and protect health globally. Announcements included the unveiling of the Climate and Health Declaration, climate health financing from partners, and transformative Guiding Principles for Financing Climate and Health Solutions established to protect health.

The First Health Day at a COP

Climate change is one of the greatest threats to human health in the 21st century. COP28 will be the first COP to host a Health Day and climate-ministerial at a COP on December 3rd. At the first ever Health Day, participants will progress solutions to reduce carbon emissions, limiting air pollution, and preventing premature deaths.

Global Action to Address Climate Health Impacts

Endorsements from 123 countries for COP28 UAE's Climate and Health Declaration.

41 endorsements from key partners of the Guiding Principles for Financing Climate and Health Solutions

Funders announce over $1bn funding to address the climate health crisis.

Further Information:

The COP28 UAE Climate and Health Declaration and full list of endorsing countries can be found here.

The COP28 Guiding Principles for Financing Climate and Health Solutions and full list of endorsers can be found here.

CC Adaptacion: ventiladores además de estufas en el exterior