Statement of Research Achievements

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Introduction Positioning, Methods and Data

Since the European heatwave of 2003 caused massive excess mortality, the health impacts of climate change have become a global concern. Climate-related health risks are jointly modulated by the frequency, intensity and duration of extreme events, local population health, and socioeconomic and environmental factors (e.g., PM2.5 and ozone), and they are highly heterogeneous across regions - making localized, regional assessment essential. Since 2005 I have studied environment-health associations in Taiwan and the wider Asia-Pacific. My methods center on distributed lag non-linear models (DLNM), random-effects meta-analysis and Bayesian hierarchical models, linking nationwide health-insurance and vital-statistics data for 23 million residents with meteorological, air-quality, satellite and reanalysis data and IPCC RCP climate scenarios, and translating exposure-response relationships into decision-relevant climate services. The following describes key findings, scholarly contributions and policy applications across five research themes.

Theme 1 Extreme Temperature, Climate Change and Human Health

Background

Taiwan is a humid, subtropical island with high air-conditioning penetration, where extreme temperatures (heatwaves and cold spells) produce strongly region-dependent health effects. I have systematically quantified the mortality and morbidity risks of ambient temperature for all-cause, circulatory, respiratory, renal, cerebrovascular and mental disorders, and have identified vulnerable sub-populations, optimal exposure indices and future projections.

Key findings (effect sizes)

- Cold-related excess health loss generally exceeds heat-related loss in Taiwan; on a 2005-2018 baseline, **circulatory-disease** mortality carries the highest cold-related risk, followed by all-cause and respiratory disease (**Public Health, 2023**).
- Extreme thresholds were defined at the 99th percentile **32°C** (heat) and 5th percentile **14°C** (cold); the elderly (>=65 y) are the most temperature-sensitive group, with effects on both hospitalization and length of stay (**J Epidemiol Community Health, 2023**).
- Extreme heat (30.1°C) significantly raised mental-disorder risk, peaking at lags of 14-21 days; among men aged 65+, all-mental-disorder risk reached **RR 1.18 (95%CI 1.11-1.25)**, with drug abuse in women 45-64 at **RR 1.33** and dementia in those 65+ at **RR 1.19** (**Int J Biometeorol, 2025**).
- In cross-national work in Ahmedabad, India, the **UTCI bio-meteorological index** (accounting for wind, solar radiation and clothing) achieved better model fit than maximum temperature alone; females were more heat-sensitive, and the local Heat Action Plan's mitigation effect was quantified (**Int J Biometeorol, 2025**).

Contribution & policy application

This work established circulatory-disease mortality as a key monitoring indicator for temperature-health associations, and showed that metropolitan Taipei is best served by human-biometeorological indicators while daily mean temperature suffices in central/southern Taiwan. Temperature-mortality estimates were adopted by the National Health Research Institutes for future-impact projection. Under combined ageing and warming, RCP projections show declining cold-related but rising heat-related mortality; the evidence has informed adaptation and early-warning policy at the Ministry of Health and Welfare, Ministry of Environment and Ministry of Labor.

Theme 2 Health Impacts and Risk Assessment of Air Pollution

Background

I examine the acute effects of particulate matter (PM2.5, PM10) and its chemical constituents, VOCs, ozone and Asian dust storms on mortality, emergency-room visits and pre-hospital emergency medical services, and have recently turned to nature-based mitigation and real-time health-risk indicators.

Key findings (effect sizes)

- Attaining the WHO air-quality guideline (**PM2.5 < 15 μg/m³**) in Taiwan is estimated to prevent about **5,571 elderly deaths** (incl. 889 cardiovascular and 934 respiratory-related) (**Air Quality, Atmosphere & Health, 2024**).
- PM constituents relate differently to specific outcomes - sulfate >17, nitrate >15, organic carbon >15 and elemental carbon >4 μg/m³ raise the risk of chest pain, out-of-hospital cardiac arrest and respiratory distress respectively - supporting routine evaluation of PM composition in air-quality management.
- Recent work quantified the **combined (interactive) effect** of PM2.5 and ozone on emergency ambulance dispatches in southern Taiwan, highlighting the burden of multi-pollutant co-exposure (**Aerosol Air Qual. Res., 2026**).
- Nature-based mitigation: a green-curtain system reduced balcony PM2.5 at low cost (**Building and Environment, 2024**); higher community green-view index and more evergreen trees were associated with lower ambient PM2.5 (**Sci Total Environ, 2024**).

Contribution & policy application

The work characterizes the health risks of PM2.5 mass and composition in Taiwan, proposes warning-relevant constituents, critical exposure windows and alert thresholds, and provides a scientific basis for regional control priorities and urban-greening planning. Long-term VOC monitoring of schoolchildren near a petrochemical complex further identified source-specific pollutants and cancer/non-cancer risks.

Theme 3 Climate Variability and Infectious Diseases in the Asia-Pacific

Background

Even in well-developed settings, climate variability alters the occurrence and transmission of infectious disease. I analyze meteorology and air quality in relation to diarrhea, gastroenteritis, enterovirus, conjunctivitis and influenza, incorporating ENSO and monsoon anomalies, across Taiwan, Nepal, the Solomon Islands and Indonesia.

Key findings (effect sizes)

- Taiwan: extreme low temperature raised all-infectious and viral diarrhea risk, extreme high temperature related only to bacterial diarrhea, and extreme heavy precipitation significantly affected cause-specific diarrhea (**Sci Total Environ, 2023**); high temperature also amplified water-outage health impacts - gastroenteritis **RR 12.1**, skin disease **RR 4.48**, eye disease **RR 40.3**.
- Solomon Islands: average temperature raised dengue-like-illness risk at a one-month lag (**IRR 2.19, 95%CI 1.09-4.37**); **La Niña** increased risk to **IRR 4.54**, while **El Niño** reduced it by 72.8-76.7% (**BMC Infectious Diseases, 2023**).
- Nepal: monsoon season raised under-5 diarrhea by **21% (IRR 1.21)**; La Niña +32%, El Niño -8%, with stronger mountain-region effects (**IRR 1.51**) (**PNAS Nexus, 2022**).
- Central Java, Indonesia: built a climate-variability-dengue risk model to support dengue control and community adaptation (**Climate Services, 2024**).

Contribution & policy application

Because ENSO and the monsoon are predictable at longer lead times than weather, these findings underpin seasonal-to-subseasonal early warning for climate-sensitive infectious disease. Through the Belmont Forum AWARD-APR project, my team has advanced evidence-based community adaptation and hygiene education, building a regionally representative climate-infectious-disease research network.

Theme 4 Health Early-Warning Systems, Climate Services and Adaptation

Background

I translate temperature-health and infectious-disease research from historical observation to real-time, seasonal and long-term climate prediction, building decision-relevant climate services that close the loop from scientific evidence to adaptation action.

Deliverables and translation to practice

- Built web-based warning prototypes for cardiopulmonary mortality and dengue risk in Taiwan, and developed the Solomon Islands Dengue-Like-Illness Early Warning System (SoSAFE), strengthening the country's disaster-prevention, public-health and data-management capacity.
- Integrated chronic-disease and dengue research with the Central Weather Bureau and Academia Sinica to automate meteorological service products and an integrated information platform combining temperature-health and dengue warnings.
- Established seasonal-to-subseasonal diarrhea warning and community-education programs for the Asia-Pacific; co-developed climate-health adaptation decision methods with the National Health Research Institutes and identified vulnerable populations and metropolitan adaptation pathways (e.g., New Taipei City).
- Supported Cathay Financial Holdings' climate-related financial disclosure (TCFD) through extreme-temperature mortality, hospitalization and medical-risk scenario analysis.

Theme 5 Water Quality, Green Chemistry and Environmental Sustainability

Background

Extending my environmental-engineering expertise, this theme spans water quality, source apportionment, energy-transition health co-benefits and institutional sustainability, bridging research and practice.

Key findings & contribution

- Systematic review of climate impacts on biochemical oxygen demand (BOD) in Asian rivers: warming accelerates microbial activity and lowers dissolved oxygen, while reduced precipitation concentrates pollutants - transboundary rivers (Mekong, Amu Darya, Ganges) are of particular concern, aligning with SDG 6 (**Sustainable Environment Research, 2025**).
- Used a grey model GM(1,1) to project dioxin (PCDD/Fs) emissions from sugarcane burning in Indonesia, averaging about **309 pg TEQ/year**, and mapped provincial annual fluxes, identifying Lampung and East Java as hotspots (**Atmosphere, 2024**).
- Reservoir eutrophication analysis, long-term river water-quality trends and source apportionment, and occupational health-risk assessment of water reuse provide a scientific basis for water-pollution management.
- Led multi-year green-chemistry public-education programs for the Ministry of Environment; assessed the health co-benefits of bioenergy replacing coal; and, as Chief Sustainability Officer, embed the SDGs and net-zero transition into institutional decision-making and University Social Responsibility (USR).

Closing

Across these five themes, my research follows a consistent arc - environmental exposure, health risk, adaptation action - from local quantification of temperature and air-pollution effects, to regional climate-sensitive infectious disease, to operational warning systems and policy, and back to water resources and institutional sustainability. The work combines scholarly originality (methodological integration and regional comparison), rigor (population-scale data and statistical modeling) and policy impact (cross-ministerial and cross-national application), and will continue to deepen research on climate-change health adaptation and the health co-benefits of the net-zero transition.

Effect sizes (relative risks/incidence-rate ratios with 95% CIs and scenario projections) are quoted from the cited journal articles; full references appear in the publication list and CV.