**Methane Early Warning Network (ME-NET)**

Team O2H: One (Environmental & Mental) Health

**Background:** Methane is one of the most important precursors to on-ground ozone and has direct and indirect environmental and health consequences. Aside from contributing to greenhouse gases, high on-ground ozone concentrations are associated with acute respiratory and mental health conditions, often resulting in the utilisation of Emergency Medical Services (EMS) including ambulances and hospitals for urgent treatment. Technological advances are rapidly improving the accuracy of environmental monitoring and the usability of environmental data including methane (E.g., UN ‘MARS’ project). Compared to the environmental implications of methane emissions, the health effects are much less well understood. This is partly because health data are difficult to access, and the temporal and geospatial scale of health data varies considerably between sources and compared to methane measures. Technological innovation like the MARS project could be harnessed to support public health systems to mitigate the effects of ozone on health outcomes, and to explore direct links between methane and health emergencies. There is an urgent need to improve understanding of how methane impacts health and to develop data-driven solutions to, a) inform public health systems, including prehospital, hospital and EMS, b) promote data trustworthiness to overcome the science hesitancy of many vulnerable communities to engage with data science, and c) support social and ecological justice taking a ‘One Health’ approach, particularly in low and middle income regions with limited incentives for corporate responsibility around monitoring and reporting emissions, leaks and flares.

**ME-NET:** Aim: To champion social and ecological justice by ***improving awareness and understanding of the relationship between methane and health outcomes, encouraging companies to reduce their footprint for climate change mitigation,*** ***increasing the visibility of ‘hidden’ voices, and improving understanding of service access inequalities.*** Our prototype has five purposes aligned with modular functions:

1. **ALERT-ME:** Synthesises environmental data (e.g., UV, NOx, CH4,) to predict moderate and high-risk environmental conditionsthat might trigger respiratory and mental health emergencies to alert users. Deep learning (DL) will be used to train the predictive ‘early warning’ model based on daily environmental and health data (e.g., numbers of hospital admissions) over time. The interface allows users to create a personal health profile (MY PROFILE) and a clinical profile (CLINIC CONNECT). MY PROFILE includes uploading geospatial data and health history to inform personalised ozone risk alerts. CLINIC CONNECT allows health services to receive regional alerts and to report data to inform patient alerts (e.g., number of beds available).

2. **REPORT CH4NGE:** Live-updates to a basemap layer recording citizen health symptoms, service accessibility, and on-ground CH4 and O3 concentrations to encourage citizen science, capture lived experience, and improve perceptions of data trustworthiness. Data will inform Deep Learning.

3. **CORPORATE RESPONSIBILITY:** Corporations can report flares and leaks and opt-in to transparency features (e.g., Twitter updates) (REPORT YOUR OSHA VIOLATION), with an option for anonymous reporting (GRASS UP YOUR BOSS). Geocoded readings will live-update on the basemap to facilitate lobbying.

4. **EXPLORE AND LEARN:** Interactive **dashboard** with map layers utilising existing data to understand links between health outcomes and methane emissions related to the role of methane independently, and as a key precursor of on-ground ozone, for individual health conditions and physical-mental multi-morbidity.

5. **OUR DATA:** Summarises how data are used to generate alerts and data sources. Includes schematic about links between CH4 and O3 (The Perfect Storm schematic).

**Future research plans**

**Background:** Understanding the intersectionality of environmental conditions and health outcomes is often inhibited by data scarcity of one or more necessary variables, the challenges associated with synthesising data across multiple geospatial and temporal scales, and data quality. Solutions to regional environmental data scarcity include global initiatives to track methane like the Copernicus Open Access Hub and the UN’S MARs project (2024). Methane super-emitters include mining operations, agricultural activities, and waste processing and disposal. Many super-emitters are located in low- and middle-income regions, for example in Asia and Africa, where corporations have few incentives to monitor and report emissions, leaks and flares. These are also regions where individual patient health data are often difficult to access. Solutions are needed that transcend ‘best case’ data availability and are elastic to varying data quality. Geographical and geospatial methods can be used to explore relationships between messy datasets while maintaining data integrity (Moore et al., 2022).

**Aim:** To pilot an integrated data platform (ME-NET) for regions with varying environmental and health data availability and quality, and with varying sources of methane super-emitters for, a) developing data synthesis approaches that are globally applicable, and b) training methane ‘early warning’ models that are robust to regional contexts.

**Research questions:**

1. To what extent can Deep Learning be used to develop an early warning system that incorporates health data in two/three regions of the world representing a microcosm of wider global variation related to data availability and quality?
2. What are the most relevant health measures for predicting physical and mental health emergencies associated with methane and ozone concentrations in two/three regions?
3. What user functions would best improve the visibility of climate change impacts, and how deliverable are these, given data availability and quality in regions?

**Summary of the research:** The research will pilot using DL/Artificial Neural Networks (Schuit et al., 2022) to train an ‘early warning’ model that incorporates best quality available historic and current/future environmental and health data and patient self-reported data for validation. This model could be integrated with existing/future platforms (e.g., MARs, infectious disease early warning systems) or operate independently by utilising open source atmospheric, weather, and ground-level data (e.g., Copernicus Open Access Hub). Incremental Learning will incorporate incoming service use and self-reported patient data to improve accuracy and identify environmental thresholds linked to severe health outcomes. Comparing and contrasting dashboard functionality between regions will reveal design challenges associated with data availability, socio-cultural context, and science literacy. Understanding regional characteristics will allow our UX/UI designers (Ethical Design Co.) to co-produce innovative modular solutions that promote data trustworthiness, science literacy, encourage citizen science, and facilitate inclusive, accessible engagement with the ME-NET dashboard. The dashboard will synthesise robust open-data (e.g., ONS) for transparency and economic sustainability. Local partnerships will encourage user engagement with dashboard co-design to promote climate response readiness and science literacy.

**Location and population:** Three regions will be involved in the research, with capacity to develop two regional dashboards to full functionality in one year and partial to full functionality in a third region, depending on timeframes for co-production. Participation by local community lived experience experts (LEEs) for co-developing the prototype may be subject to cultural factors like seasonal employment and agricultural timeframes. Including data rich and data scarce regions in the research will elucidate challenges and opportunities for expanding the application of the dashboard globally. Selecting field sites with varying sources of CH4 in data scarce regions (e.g., mining in Ghana and waste sites in Bangladesh) will inform dashboard and app development for methane emitters with more consistent emissions, like waste sites, and with erratic emissions that are difficult to predict, like flares from mining sites. Including the UK as a ‘data rich’ region will inform parameters for regions with ‘messy’ data and serve as a social justice lobby focus for encouraging low- and middle-income regions to support transparent and trustworthy data science for justice.

**Research environment & partners:** The research will be delivered by our demographically and career-stage diverse team, in collaboration with local (Lincolnshire and UK) and international partners who will facilitate access to existing stakeholder groups to inform prototype co-design and development. Established researchers (MG, NS) will mentor ECRs (HM, JA) to facilitate international partnerships, enabling skill and knowledge transfer within and beyond the research team. Our national partners include The Met Office, an HEI consortium (Loughborough, Essex, Northumbria and Lincoln), and regional PPIE groups (e.g., CaHRU’s HAPPI Group in Lincolnshire). Our international partners in Bangladesh include the International Institute for Diarrheal and Disease Research, specialising in respiratory infection research (regional co-lead: Dr Shehrin Mahmood). Our partners in Ghana include the University of Ghana (regional co-lead: Dr Ebenezer Amankwaa).

“*The proposal (ME-NET) addresses the urgent need to improve methane emissions reporting, and lobby industry to collaborate. The research will make an immense contribution to Ghana’s efforts toward our Nationally Determined Contributions (NDCs) and combating the impacts of climate change*.” (Dr Amankwaa, University of Ghana).

**Stakeholder Engagement**: Regional policy makers, industry representatives, clinical practitioners, operators of clinical services, and patient public involvement and engagement groups (PPIE) will be engaged to inform the co-design of prototypes for each region through a series of ‘innovation labs’. An engagement board will be established including representatives from each of two/three regions. The research employs UX/UI designers with specific sustainability and ethical ethos, including prioritising, “*creative and longer-lasting human-centred solutions to meet real global needs*” (Ethical Design Co.). An Ethical Design Co. representative will attend in-person co-design ‘innovation labs’ to ensure that user functions are co-developed with communities for regional and cultural appropriateness.

*“Establishing a network to promote social and ecological justice related to the health impacts of methane in Bangladesh is a critical priority.”* (Dr Mahmood, ICDDRB).

**Programme of research activities:**

***Months 0-3:*** Complete ethical protocol and research equality impact assessment, establish Programme of Engagement with relevant PPIE and stakeholder groups, arrange field site visits (UK/Bangladesh/Ghana) (HM), and begin DL model development (JA). Establish an engagement board (PPIE, LEE and other stakeholder groups (NS, MG), and hold initial online meetings with stakeholders, engagement board, and UX/UI designers to begin exploring feasible design elements (JA, HM). Collate open-source regional data (EH).

***Months 3-9:*** Conduct site visits in the UK (JA, HM), Ghana (JA) and Bangladesh (HM), hold monthly online meetings with PPIE groups and engagement board to co-develop prototypes iteratively through feedback (JE, HM, MG). Develop prototypes (TEAM).

***Months 9-12:*** Deliver prototypes to PPIE groups and engagement board for final feedback and co-design (JA, HM). Platform goes live.

**References:**

Moore, et al. (2022). An exploration of factors characterising unusual spatial clusters of COVID-19 cases in the East Midlands region, UK. *Land Urb Plan*, *219*, p.104299.

Schuit, et al., 2023. Automated detection and monitoring of methane super-emitters using satellite data. *Atmos Chem Phys Disc*, pp.1-47.

**BUDGET**

**Salaries:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Name | Justification | Months | % time | Total (£) |
| John Atanbori | ML expertise, develop dashboard prototype iteratively throughout the research period. Conduct field work in Ghana and the UK to consult with community, industry and clinical stakeholders. | 12 | 30 FTE | 17112.30 |
| Harriet Moore | Coordinate in-country and online innovation labs, develop ethics assessment. Collate health data for all field sites. Conduct field work in Bangladesh and UK to consult with community, industry and clinical stakeholders. | 12 | 30 FTE | 17667.38 |
| Edward Hanna | Collate environmental data for all field sites, coordinate representation of UK industry sectors in stakeholder engagement board, consult on dashboard development. | 12 | 2 FTE | 2459.89 |
| Mark Gussy | Coordinate monthly innovation labs and PPIE involvement in stakeholder engagement board, consult on clinical dashboard functions. Mentor ECRs (JA, HM) | 12 | 2 FTE | 3388.02 |
| Niro Siriwardena | Coordinate representation of UK public health sector in stakeholder engagement board, consult on clinical dashboard functions. Mentor ECRs (JA, HM). | 12 | 2 FTE | 3298.33 |

**Materials and consumables:**

|  |  |  |
| --- | --- | --- |
| Description | Justification | Total (£) |
| N/A | N/A | N/A |

**Equipment:**

|  |  |  |
| --- | --- | --- |
| Description | Justification | Total (£) |
| N/A | N/A | N/A |

**Access charges:**

|  |  |  |
| --- | --- | --- |
| Description | Justification | Total (£) |
| N/A | N/A | N/A |

**Travel and subsistence:**

|  |  |  |
| --- | --- | --- |
| Description | Justification | Total (£) |
| Lincoln-Bangladesh flight and transfers (1 x person, 1 x trip) | Data-scarce field site, waste disposal super-emitters. In-country field work to establish PPIE groups, conduct community, industry and clinical consultation to inform dashboard development, establish stakeholder engagement board for online innovation labs. | 1100 |
| Bangladesh accommodation (1 x person, 1 x person, 5 x nights) | As above. | 550 |
| Bangladesh subsistence (1 x person, 5 x nights) | As above. | 120 |
| Lincoln-London rail fare (2 x people, 2 x trips) | Data-rich field site, agricultural and mining super-emitters. UK based field work to conduct industry and clinical consultation to inform dashboard development. | 400 |
| London accommodation (2 x night, 2 x people, 2 x trips) | As above. | 1120 |
| London subsistence (2 x nights, 2 x people, 2 x trips | As above. | 280 |
| Lincoln-Ghana flights and transfers (1 x person, 1 x trip) | Data-scarce field site, mining super-emitters. In-country field work to establish PPIE groups, conduct community, industry and clinical consultation to inform dashboard development, establish stakeholder engagement board for online innovation labs. | 1150 |
| Accommodation (1 x person, 5 x nights) | As above. | 600 |
| Ghana subsistence (1 x person, 5 x nights) | As above | 120 |

**Miscellaneous/other:**

|  |  |  |
| --- | --- | --- |
| Description | Justification | Total (£) |
| Stakeholder engagement board participation reimbursement 10 x people (2 hours) per 12 x month | Supporting diversity and inclusion by compensating stakeholder representatives from each of three regions to attend monthly online engagement board innovation labs to ensure dashboard is co-designed accessibly, sustainably, and ethically. | 6000 |
| Stakeholder/LEE participation in community-based innovation labs (20 people x 3 regions x 2 labs) | Supporting accessibility, usability and sustainability by co-designing the dashboard prototype with communities from three regions. Innovation labs will promote data credibility and trustworthiness, ensuring the dashboard facilitates safely data sharing and use. LEE participation will facilitate social mobility, promote knowledge transfer and sharing between researchers and LEEs, and provide opportunities for skill development, encouraging within country research culture and environment. | 9000 |
| Web development subcontract, inclusive of site travels | Some regions involved in the research include communities with technology hesitancy and low science literacy. Facilitating co-production between our partners and UX/UI designers will ensure usability, and representation of diverse user needs incorporating culturally appropriate interface features. | 35634 |

**Summary of costs requested:**

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| --- | --- |
| Description | Total (£) |
| Salaries | 43925.92 |
| Materials & consumables | N/A |
| Equipment | N/A |
| Access charges | N/A |
| Travel & subsistence | 5440 |
| Miscellaneous/other | 50634 |
| Grand Total | **99999.92** |

\*Final budget will include carbon off-setting