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| Institution: University of Surrey | | |
| Unit of Assessment: 12 Engineering | | |
| Title of case study: Shaping urban air pollution guidance and mitigation measures | | |
| Period when the underpinning research was undertaken: 2009-2020 | | |
| Details of staff conducting the underpinning research from the submitting unit: | | |
| Name(s): | Role(s) (e.g. job title): | Period(s) employed by submitting HEI: |
| Professor Prashant Kumar | Chair in Air Quality and Health | 2009 - present |
| Dr Alex Hagen-Zanker | Senior Lecturer | 2012 - present |
| Period when the claimed impact occurred: 2013 - 2020 | | |
| Is this case study continued from a case study submitted in 2014? N | | |
| <p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Annually, air pollution results in >7 million premature deaths worldwide. With a mission to realise 'clean air for all', research by the Global Centre for Clean Air Research (GCARE), has underpinned policy change, enhanced guidance, and mitigation products that are reducing the effect of air pollution in urban environments.</p> <p>Research has influenced the development of policy and guidelines for Greater London and across the UK through Defra and Public Health England.</p> <p>Kumar's research on green infrastructure (GI) has provided an evidence base for more effective use of these measures. The development of free to use guidelines and toolkits are engaging the public and raising awareness of urban air pollution and mitigation strategies.</p> | | |
| <p>2. Underpinning research (indicative maximum 500 words)</p> <p>Research on air quality at the University of Surrey, led by Kumar, has focused on the sources, atmospheric concentrations and behaviours of a range of pollutants in different environments and countries including the UK, India and Egypt. In response to this ongoing work, GCARE was established in 2017 to extend Surrey's ground-breaking research and offer real-world solutions to reduce pollution exposure. Numerous studies have been undertaken with collaborators across the world, resulting in a large body of air pollution expertise.</p> <p>Assessing Exposure</p> <p>Kumar worked extensively on dispersion and dispersion modelling from 2007-2011, developing new, or improving the capabilities of existing, dispersion models to support the design of effective mitigation strategies for urban environments [R1]. This formed the basis for further exploratory research on the impact of air pollution exposure on groups such as commuters and in-pram babies.</p> <p>Research examining the exposure of different socio-economic groups to pollutants during commuting in London found the following: (i) higher concentrations of all pollutants - especially particulate matter (PM) - were observed in underground carriages with openable windows and in underground stations; (ii) concentrations of pollutants during the morning peak were between 13-43% higher than during the afternoon or evening peak, depending on the</p> | | |

pollutant and; (iii) there are environment injustices in the quantity and source of exposure experienced by London commuters [R2].

In 2019, Kumar led a team assessing particle mass and number exposure of in-pram babies at different route segments to understand their physicochemical characteristics and the exposure differences between in-pram babies and adults. The results demonstrated that in-pram babies can be exposed to 60% more pollutants than adults [R3].

Further research extended this understanding, mimicking the exposure of babies in different types of pram to multiple air pollutants. One notable result was that mitigation measures – in the form of pram covers - reduced concentrations of small-sized particles by as much as 39% (fine particles) and 43% (coarse particles). Results reinforced the need to mitigate exposures to in-pram babies, especially at urban pollution hotspots such as busy congested roads, bus stops, and traffic intersections [R4].

Pollution Exposure Reduction

GCARE research has assessed the effectiveness of different types of green infrastructure (GI) [R5] and evaluated the impact of wind direction and density of vegetation on reducing the concentrations of different pollutants. The research demonstrated the mitigation potential of vegetation barriers in limiting near road nanoparticle exposure [R6]. A further study [R7] investigated the influence of roadside GI configurations (trees, hedges and tree-hedge combinations) on concentrations of particulate matter. Six different real-world scenarios were evaluated finding average concentration reductions of ~52%, 30%, 31%, 17% and 15% for black carbon, particle number concentration, and particulate matter of three sizes (sub-one micrometre, sub-2.5 micrometre and sub-10 micrometre), respectively. This research enhanced the understanding of air quality modifications for multiple pollutants due to different GI configurations, thus supporting the formulation of appropriate guidelines for GI design.

3. References to the research (indicative maximum of six references)

- [R1] Kumar, P., Ketzel, M., Vardoulakis, S., Pirjola, L., Britter, R. (2011). Dynamics and dispersion modelling of nanoparticles from road traffic in the urban atmospheric environment - A review. *Journal of Aerosol Science*, 42(9), pp. 580-603. DOI: [10.1016/j.jaerosci.2011.06.001](https://doi.org/10.1016/j.jaerosci.2011.06.001)
- [R2] Rivas, I., Kumar, P., Hagen-Zanker, A. (2017). Exposure to air pollutants during commuting in London: are there inequalities among different socio-economic groups? *Environment International*, 101, pp. 143-157. DOI: [10.1016/j.envint.2017.01.019](https://doi.org/10.1016/j.envint.2017.01.019)
- [R3] Kumar, P., Rivas, I., Sachdeva, L. (2017). Exposure of in-pram babies to airborne particles during morning drop-in and afternoon pick-up of school children. *Environmental Pollution*, 224, pp. 407-420. DOI: [10.1016/j.envpol.2017.02.021](https://doi.org/10.1016/j.envpol.2017.02.021)
- [R4] Sharma, A., Kumar P. (2020). Quantification of air pollution exposure to in-pram babies and mitigation strategies, *Environment International*, 139, Article 105671 DOI: [10.1016/j.envint.2020.105671](https://doi.org/10.1016/j.envint.2020.105671)
- [R5] Abhijith KV, Kumar P., Gallagher J, McNabola A, Baldauf R, Pilla F, et al. (2017). Air pollution abatement performances of green infrastructure in open road and built-up street canyon environments – A review. *Atmospheric Environment*, 162, pp. 71-86. DOI: [10.1016/j.atmosenv.2017.05.014](https://doi.org/10.1016/j.atmosenv.2017.05.014)
- [R6] Al-Dabbous, A.N., Kumar, P. (2014). The influence of roadside vegetation barriers on airborne nanoparticles and pedestrians exposure under varying wind condition. *Atmospheric Environment*, 90, pp. 113-124. DOI: [10.1016/j.atmosenv.2014.03.040](https://doi.org/10.1016/j.atmosenv.2014.03.040)

[R7] Abhijith, K.V., Kumar, P. (2019). Field investigations for evaluating green infrastructure effects on air quality in open-road conditions. *Atmospheric Environment*, 201, pp.132-147. DOI: [10.1016/j.atmosenv.2018.12.036](https://doi.org/10.1016/j.atmosenv.2018.12.036)

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- H2020, SCAPE, Project: 689954 (Sept 2016 – Nov 2019), €664,337, University of Surrey
- ESRC, ASTRID, Project: ES/N011481/1 (Oct 2015 – Sept 2018), £230,310, Hagen-Zanker, A.
- NERC, ASAP-Delhi, Project: NE/P016510/1 (Nov 2016 – Mar 2022), £311,638, Kumar, P.

4. Details of the impact (indicative maximum 750 words)

The devastating effects of air pollution are well known and experienced throughout the world. Surrey's research into air pollution exposure and mitigations have influenced policy and guidelines and informed practical solutions thus contributing to the goal of clean air for all. Further, GCARE has increased public understanding of the issue and contributed locally to provide guidance and solutions, all drawing on its research heritage.

1. Influencing Policy and Guidelines

In 2016-2017, Kumar was invited to join the Institution of Civil Engineers *Air Pollution Task Force* and applied core research insights [R1] to the development of the '**Engineering Cleaner Air**' report [S1]. This report examines the transport, planning and water infrastructure systems, alongside new technologies and construction industry practices, all of which can be adapted to reduce air pollutant emissions. Aimed at policy makers and industry leaders, the report provided a series of recommendations developed by the Task Force.

Similarly, Kumar's research [R5] contributed to the *Public Health England* report: '**Review of interventions to improve outdoor air quality and public health**', 2019 [S2]. This report draws specifically on Kumar's GI research, highlighting "<...> the need for careful planning and consideration of tree placement and vegetation type. There can be a number of unintended adverse consequences if the wrong species of plants or location are chosen, such as increased releases of VOCs or pollen that may affect people with respiratory illness or pollen allergies and impacts on pollutant dispersion." [S2]

Kumar's research contributed to the development of the *Air Quality Expert Group* reports prepared for Defra; '**Impacts of Vegetation on Urban Air Pollution**', 2018 [S3] and '**Ultrafine Particles (UFP) in the UK**, 2018 [S4]. These reports reinforce the opportunities for GI to mitigate urban air pollution and the scale of the issue in the urban environment, drawing on Kumar's research [R1, R6, respectively] .

In 2019, the *Greater London Authority* commissioned a further report on GI, co-authored by the Universities of Surrey (lead Kumar), and Birmingham, with Transport for London. The report - '**Using Green Infrastructure to Protect People from Air Pollution**' [S5] - sets out unprecedented, best-practice guidance for GI implementation in roadside environments, with its recognised co-benefits of promoting physical and mental wellbeing, and of encouraging biodiversity. This best-practice guidance is critical for urban planning departments, infrastructure design consultants and contractors to make the most effective use of GI.

2. Development of mitigation measures

2.1 Mitigating Exposure Guidance

Recognising that many people live, work and spend time during their commute in near-road environments where pollutant concentrations usually remain high and, in an effort to ensure rapid and easy to access advice, GCARE have extended their guidance [S2, S3, S5] into the local community. The freely available guidance '**Mitigating Exposure to Traffic Pollution In and Around Schools: Guidance for Children, Schools and Local Communities**' [S6] was the result of a series of co-designed studies carried out with local schools. This guidance has been promulgated by >20 organisations both in the UK and internationally and has received significant

uptake; downloads exceed 1,000 with over 2,000 views (as at December 2020). Requests for the guide have reached beyond the local aspiration and the guide has been translated into 10 languages to meet global demand.

2.2 Brizi Baby

GCARE have provided technical advice and testing of the 'Brizi Baby', a smart, portable cushion designed to fit any child stroller to provide a protective air-shield around the baby's breathing perimeter by circulating a continuous flow of clean air. The Brizi Baby featured on the TV series *Dragons Den* in 2018, receiving a six-figure investment from Touker Suleyman [S7]. The company was due to start production in early 2020, with John Lewis lined up as stockist, but has been delayed as a result of the Covid pandemic.

3. Contributing to Public Understanding

Through media engagement, including the BBC and The Times in the UK with readerships in excess of 100 million and 16 million per month, respectively [S8] GCARE's work has had significant impact in raising awareness and conveying key messages about the issue of poor air quality and mitigation solutions. GCARE is passionate about engaging publics in their research and being an active part of the solutions.

Referring to Kumar's local air pollution work in 2019/20, Guildford Borough Council concludes: *"The University of Surrey's iSCAPE (Improving the Smart Control of Air Pollution in Europe), GCARE (Global Centre for Clean Air Research) and Living Lab projects have made Guildford a world-class hub for research and innovation in tackling air pollution and climate change. Their work with local communities, including schools and businesses, has improved air quality in the borough whilst creating strategies of worldwide importance."* [S9]

The research on GI [R6, R5] has resulted in the development of practical tools and guidance available to all, including the HedgeDATE tool, a web-based application that offers GI design for air pollution exposure abatement, and guidance document '**Implementing Green Infrastructure for Air Pollution Abatement: General Recommendations for Management and Plant Species Selection**' which has been downloaded over 1,500 times. [S10]

5. Sources to corroborate the impact (indicative maximum of 10 references)

[S1] Institution of Civil Engineers, 2017. Engineering Cleaner Air: A report into civil engineering solutions to London's air pollution <https://www.ice.org.uk/ICEDevelopmentWebPortal/media/Documents/Regions/UK%20Regions/ICE-Engineering-Cleaner-Air-Report.pdf> [See p.39, Rivas et al. (2017)]

[S2] March 2019, Public Health England report: Review of interventions to improve outdoor air quality and public health <https://www.gov.uk/government/publications/improving-outdoor-air-quality-and-health-review-of-interventions> [See p.259, Abhijith et al. (2017)]

[S3] July 2018 Defra report : Impacts of Vegetation on Urban Air Pollution https://uk-air.defra.gov.uk/library/reports.php?report_id=966 [See p.10, Al-Dabbous & Kumar (2014); p.15, Abhijith et al. (2017); Gallagher et al. (2015)]

[S4] July 2018 Defra report: Ultrafine Particles (UFP) in the UK https://uk-air.defra.gov.uk/library/reports.php?report_id=968 [See p.15, Kumar et al. (2011); p.16, Kumar et al. (2014); p.77, Kumar et al. (2011); p.78, Kumar et al. (2009)]

[S5] Greater London Authority, 2019. Using Green Infrastructure to Protect People from Air Pollution <https://www.london.gov.uk/WHAT-WE-DO/environment/environment-publications/using-green-infrastructure-protect-people-air-pollution>

[S6] June 2020, Mitigating Exposure to Traffic Pollution In and Around Schools: Guidance for Children, Schools and Local Communities Guidelines and views, download statistics <https://zenodo.org/record/3754131#.YDPtkOj7RaR?>

[S7] Brizi Baby Product website <https://www.brizi.com/>

[S8] Compilation of media attention, including 7 BBC news articles, and pieces in the Telegraph, Times, Daily Mail, The Mirror and The Sun. - PDF

[S9] Article on Tackling air pollution from Guildford Borough Council, <https://www.guildford.gov.uk/article/24517/Our-Progress-In-Tackling-Climate-Change>

[S10] Implementing Green Infrastructure for Air Pollution Abatement: General Recommendations for Management and Plant Species Selection https://figshare.com/articles/figure/Considerations_regarding_green_infrastructure_implementation_for_improved_air_quality/8198261