Final Report
Executive Summary

HSC Public Health Agency
Research and Development

HSC R&D Division Final Progress Report

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HSC Public Health Agency
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HSC R&D Division Award Details

HSC R&D File Reference	COM/5633/20
HSC R&D Funding Scheme	Opportunity-Led Research Award
Project Title	A Vision of Healthy Urban Design for NCD Prevention
Award Holder Name (Employer)	Professor Ruth Hunter (Queen's University Belfast)
Host Research Organisation	Queen's University Belfast
Award Duration	2 years and 14 days
Award Start Date	01.04.22
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Name of Lead Supervisor: ***(only applicable to training awards)***	

Signature

Award Holder Signature:	
	Date:

HSC Public Health Agency
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Evidence Brief

(1 page: which may be used for dissemination by HSC R&D Division)

Why did we start? (The need for the research and/or Why the work was commissioned)	Long-term health problems like cancer, heart disease, diabetes, asthma, and mental health issues are some of the main reasons people die in the UK and Australia. These are called non-communicable diseases, or NCDs. The way our cities are designed—things like parks, transport, housing, and walkways—can help prevent these diseases and improve how long and how well people live. But even today, experts still do not fully know the best ways to design healthier cities.
What did we do? (Methods)	In Phase 1, we used artificial intelligence to study detailed aerial images of cities in the UK and Australia with more than 100,000 people. This helped us spot features in the built environment—like roads, buildings, and green spaces—and see how they relate to local health issues like cancer, heart disease, and diabetes. In Phase 2, we combined this information with long-term health data to explore how things in our surroundings—like access to parks or walkable streets—might lead to healthier or unhealthier lifestyles, and how that connects to disease. In Phase 3, we estimated how changing parts of city design could improve people's health. In Phase 4, we created an easy-to-use online tool to help city planners, designers, and policymakers make decisions that support healthier communities.
What answer did we get? (Findings)	We found that certain ways cities are built—like the layout of streets and access to open spaces—can affect people's risk of getting long-term health problems. Some health issues are more strongly linked to city design than others, meaning that changing certain parts of how we build cities could make a bigger difference to people's health.
What should be done now? (Practice/Policy Implications and/or Recommendations)	This study shows how the design of our cities is linked to the risk of long-term health problems. These findings can help guide future planning and policies. We are developing a tool called *City Vision* that lets city planners, health workers, researchers, community groups, and the public explore how changes to city design could affect people's health.

Final Report

(no more than 20 pages)

Please structure the report using the headings below

Background

Managing growing city populations is a big public health challenge around the world. People need safe food, clean air and water, good housing, transport, and strong social connections to stay healthy. But even in wealthy places like the UK and Australia, some neighbourhoods are designed in ways that increase the risk of serious long-term illnesses, known as non-communicable diseases, or NCDs [e.g., 1-3]. These include heart disease, type 2 diabetes, cancer, mental health problems, and more.

Poor city design can lead to health problems by making it harder to be physically active, exposing people to air pollution, making unhealthy food easier to get than healthy food, and creating social isolation. Even walking or cycling in poorly designed cities can be risky due to traffic dangers. Cities that rely too much on cars and fossil fuels also make these problems worse [4-7].

Urban planning decisions—like how dense an area is, whether homes are near shops and parks, and how easy it is to walk, cycle, or take public transport—can shape people's daily habits and impact their health both directly (like through more exercise) and indirectly (like through less air pollution or heat). These diseases are often caused by a mix of lifestyle choices, social influences, and the environment people live in [8-14].

Importantly, non-communicable diseases do not affect everyone equally. People with lower income, less education, or fewer resources are more likely to get these diseases and suffer more from their effects [15]. That's why improving city design—so it supports healthy choices for *everyone*—can help reduce health problems and social inequalities at the same time [16]. To do this well, we need new, smart tools that can handle the complexity of modern cities and how people live in them.

Aims and objectives

Our main goal was to create new knowledge and tools to help city planners and health professionals understand how to design healthier cities and prevent long-term diseases, like heart disease, diabetes, and cancer.

The project focused on five key aims:

1. Use advanced computer tools and artificial intelligence to study how different types of city design are linked to health problems in cities across the UK and Australia.
2. Explore how differences in city design—both between cities and within them—are connected to health inequalities.
3. Use large health and mapping datasets to better understand how city design may lead to certain diseases over time.
4. Estimate how much health could improve if we made specific changes to the way cities are built, from small local changes to larger-scale ones.
5. Build an easy-to-use online tool to help city planners, decision-makers, and the public make choices that support healthier communities.

Methods

Our research had four main phases:

1. We looked at how city and neighbourhood design are linked to long-term health problems, using large-scale data, satellite images, and health information from the population.

2. We explored how things like access to parks, walkability, or traffic might lead to poor health over time.
3. We estimated how much we could reduce disease and health inequalities by making practical changes to the way cities are designed.
4. We created an interactive online tool to help city planners and policymakers make better decisions for healthier communities.

Phase 1 – Building the evidence on the links between city design and health

In the first phase of our research, we focused on understanding how different features of city design are linked to long-term health problems across the UK and Australia. Using methods introduced by Thompson and colleagues [17], we studied all cities with more than 100,000 people—covering about 90% of the population in both countries.

We gathered detailed images of these cities using maps, satellite pictures, aerial views, and street-level photos. Then, we used advanced artificial intelligence programs to scan the images and identify features like footpaths, roads, intersections, parks, shops, green spaces, and more. Each part of the city—about the size of a 30m by 30m square—was analysed in this way.

We counted the features in each area and grouped neighbourhoods based on the types of features they had, using special data tools. Next, we combined this urban design data with health information, while taking into account differences in things like income and age across neighbourhoods.

Finally, we used a powerful type of computer modelling to predict where certain diseases and health risks are more likely to occur, based on the urban features present. This helped us create a detailed health "meta-map" that shows how different combinations of city features relate to health outcomes. These insights can be applied to other real places—whether existing or still being planned.

Figure 1 shows an example of how we carried out the analysis, using map data from OpenStreetMap and health data from the UK Biobank.

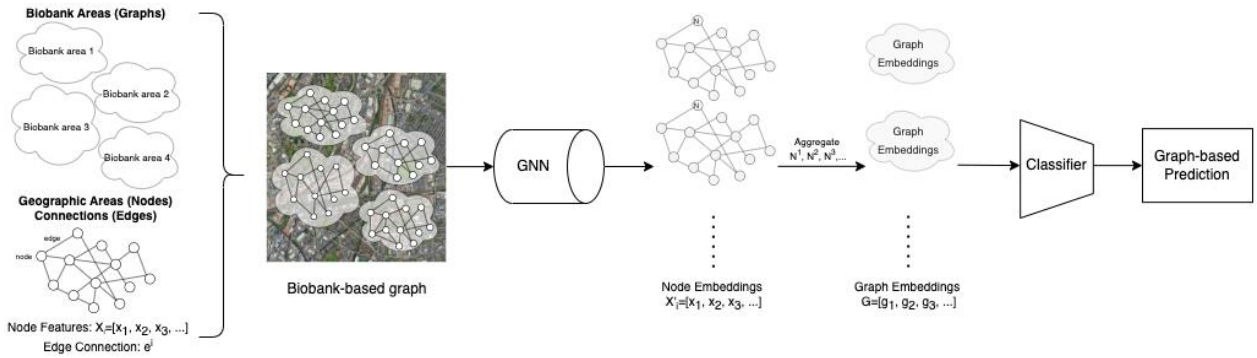

Figure 1. Example of analysis pipeline. GNN: graph neural network.

Phase 2 – Exploring how city design may cause health problems

In this phase, we used detailed health and location data from the UK Biobank—a large study of around 500,000 adults in the UK—to look at how different aspects of city design may lead to health issues over time. The data included information about people's age, income, education, lifestyle habits (like smoking or exercise), and the design of their neighbourhoods (such as green space, building types, and street layout).

To understand how city design might cause or contribute to diseases, we used a special type of computer model called a Bayesian network. This model shows how different factors are connected and how changes in one (like access to parks) might lead to changes in others (like physical activity or the risk of disease). Each factor—like age, income, green space, or disease risk—is shown as a "node" in the network, and the lines between them show possible cause-and-effect links.

This method also helped us see how social differences—like income or education—might change the way city design affects health. For example, it can tell us if people in lower-income areas are more affected by poor walkability than those in higher-income areas.

Figure 2 shows an example of this network, focused on breast cancer.

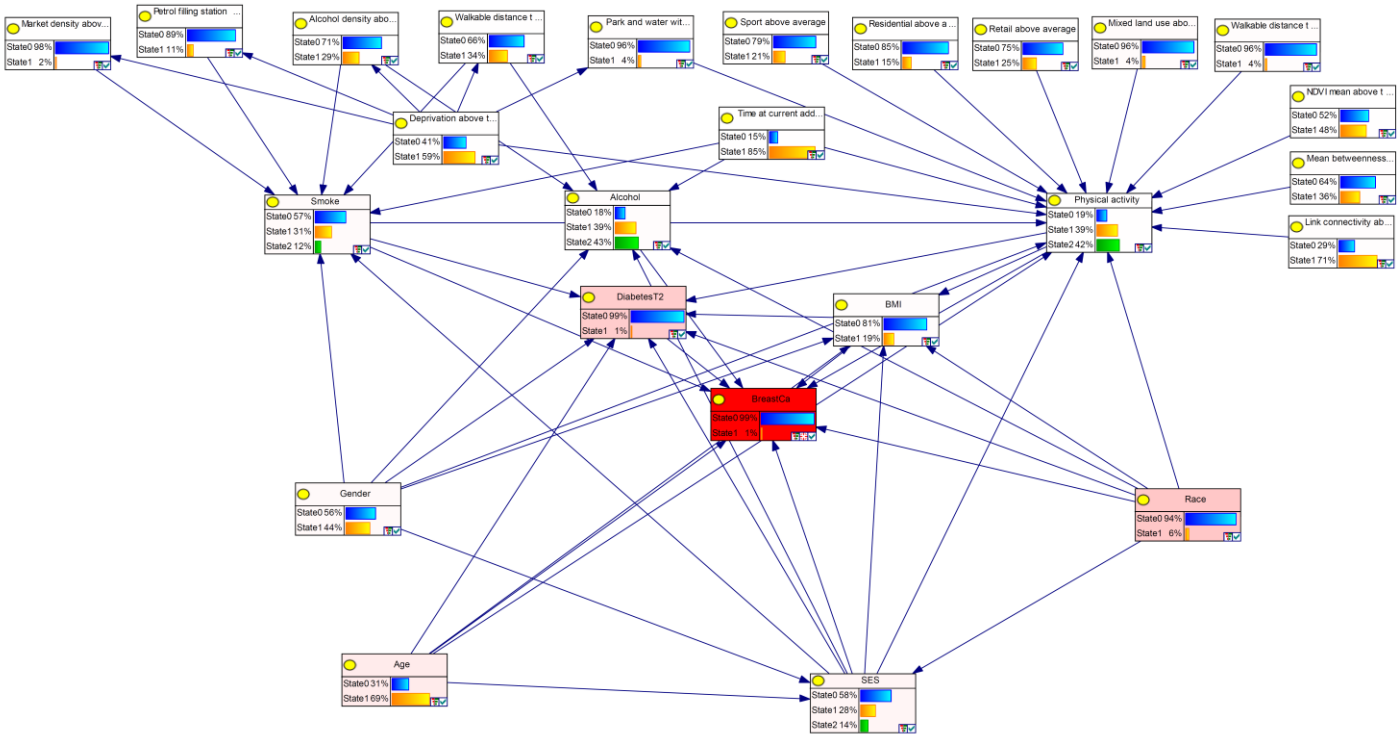

Figure 2. Bayesian network used in the analysis of breast cancer. Each box is a factor investigated in this study. The numbers inside the boxes show how common each factor was among people in the study. Arrows indicate cause-and-effect links between variables (cause → effect).

Phase 3 – Estimating the health benefits of better city design

In this phase, we aim to estimate how much people's health could improve if we made practical changes to how cities are designed. Using the data from Phases 1 and 2, we want to estimate how changes—like adding green space or reducing car use—could reduce disease, prevent early deaths, and improve overall quality of life.

Because we looked at real cities and neighbourhoods, we are able to compare each area with healthier counterparts. This helps to show what kind of changes might be possible in the short term. We can also compare places to the healthiest city areas in the country to understand the potential benefits of more ambitious long-term changes.

In addition, we want to use a type of artificial intelligence program to help visualise what these improved city designs could look like. This included showing how cities might move from being car-heavy and polluted to more walkable and clean—and what that would mean for reducing disease and making cycling safer [18, 19].

Phase 4 – Creating a practical tool for real-world use

In the final phase, we began building an easy-to-use online platform called City Vision. This tool will bring together everything we learned in Phases 1 to 3 and present it in an interactive way so users can explore the findings and make more informed decisions.

City Vision is being developed together with the people who will actually use it—such as city planners, public health workers, community organisations, researchers, and the general public. By involving these users from the start, we are making sure the tool is useful, easy to navigate, and fits their real-world needs.

We also ran a workshop with 12 participants in the UK to better understand what users need from the tool, what their goals are, and how the platform can support them in taking action to prevent disease through better urban design.

Personal and Public Involvement (PPI)

From the beginning of the project, we've worked closely with a wide range of people and organisations to shape and guide our research. These stakeholders—across different sectors—helped us design and manage the study to make sure it reflects real-world needs. We built on trusted partnerships from previous projects to ensure strong collaboration with the public and expert advisory groups.

To make sure the tools and findings from Phases 1 to 3 would be useful in practice, we also ran a workshop with 12 participants from across the UK. These included people from local governments, public health, community groups, and research. During the session, we shared an early version of the City Vision platform and gathered valuable feedback on how to improve its layout, usability, and usefulness for decision-making. Their input will help to shape the platform so that it meets the needs of the people who will rely on it.

Findings

The COVID-19 pandemic caused significant delays to the project's activities and timelines. Despite these challenges, we were still able to make progress in all four phases of the research. Below, we highlight what was achieved.

Phase 1 – Building the evidence on the links between city design and health

This phase produced two main outcomes:

1. A new way to analyse images of cities using advanced computer models (called semi-supervised graph neural networks). These models can now be used in other large-scale studies to examine the design and features of neighbourhoods across millions of locations.
2. A real-world example of how these models were used with UK Biobank health data to study the link between urban design and health risks.

The computer model performed very well in identifying different parts of the city—like bike lanes, footpaths, roads, buildings, green spaces, and sports facilities. Early results are available in a preprint here: https://doi.org/10.48550/arXiv.2208.08047.

We then used this model with map data from OpenStreetMap to look at how well-connected each neighbourhood is, and then on how the different levels of road connection relate to certain health risks and diseases (like type 2 diabetes, depression, and lung cancer) using data from the UK Biobank. To visualise the results, we created graphs that grouped similar cities together based on their urban design. This helped us see which city layouts are linked to better or worse health outcomes (Figure 3).

For example, the model could predict how much people walked in a neighbourhood just by looking at the local road network. When we removed the road network data, the predictions were much worse—showing how important street layout is for influencing healthy behaviour.

We are now working on expanding this model to explore how other parts of city design (identified from images) are linked to health risks in people across the UK.

Figure 3. Graphs showing health patterns across UK cities based on their design. Each dot represents a city from the UK Biobank sample. Blue dots show cities where rates of certain diseases or health risk factors are **above average**. Red dots show cities **below average**. The closer the dots are to each other, the more similar those cities are in terms of urban design and health outcomes.

Phase 2 – Exploring how city design may cause health problems

Table 1 presents early findings from a model that shows what could happen to the risk of developing nine common diseases if we improved or worsened features of the urban environment. We looked at things like access to parks, how densely people live, how mixed the land use is (e.g., shops and homes closer to each other), and how close public transport is. We adjusted for other important factors such as area-level deprivation and personal characteristics like age and sex.

The results suggest that improving the urban environment could slightly reduce the risk of several major health conditions. For example, the chance of new cases could drop by 1 percentage point for lung cancer, 2 percentage points for heart disease, 3.2 percentage points for dementia, 1.6 percentage points for depression, and 1.5 percentage points for type 2 diabetes.

However, changes to the urban environment did not seem to impact the rates of bowel cancer, breast cancer, prostate cancer, or chronic respiratory disease. Also, making the urban environment worse did not appear to increase risks for these conditions.

Our next step is to explore how these effects vary depending on people's background—like income or education—to better understand how city design influences health inequalities.

Table 1. Probability of new cases of non-communicable diseases for UK Biobank participants if we improved or worsened the design of UK cities.

Disease	Observed probability (%)	Estimated probability (%) under best case	Estimated probability (%) under worst case
Bowel cancer	1.1	1.2	1.0
Breast cancer	0.9	0.9	0.9
Lung cancer	3.2	2.2	3.1
Prostate cancer	0.8	0.8	0.8
Chronic obstructive pulmonary disease	2.0	1.7	2.1
All-cause cardiovascular disease	24.1	22.1	23.7
All-cause dementia	12.5	9.3	12.3
Depression	8.6	7.0	8.5
Type 2 diabetes	7.5	6.0	7.4

Phase 3 – Estimating the health benefits of better city design

This phase relies heavily on the results from Phases 1 and 2. So far, we have gathered and prepared key background data for all UK cities with over 100,000 people. This includes data on things like how active people are, smoking and alcohol habits, consumption of ultra-processed food, air pollution levels, and overall health burden. We have also developed the code needed to run the analysis. However, we have not been able to move forward with this phase yet. We plan to complete it once the final results from the earlier phases are ready, using other resources available to our team.

Phase 4 – Creating a practical tool for real-world use

The City Vision platform was co-designed with input from 12 participants during a dedicated workshop. The current version is still in development and is being tested (beta phase). It can be accessed at www.cityvision.ada.hal.davecutting.uk, but please note that it's not yet ready for public release. We will continue to update the platform as more results become available from Phases 1 to 3 of the project.

Publications linked to this project

Nice K, Thompson J, Zhao H, et al. City designs affect transport mode choice and exposure to health risks during and after a crisis: a global observational study. Lancet Planet Health. Under review.

Garcia L, Hafezi M, Lima L, et al. Future-proofing cities against negative city mobility and public health impacts of impending natural hazards: a system dynamics modelling study. Lancet Planet Health. Under review.

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Conclusion

Our research used advanced artificial intelligence methods, large datasets of population and images of cities, and techniques to understand cause-and-effect relationships. This helped us study more locations and people and increased the reliability of our findings. We found that certain types of urban design are likely linked to risk factors and outcomes for non-communicable diseases. We also discovered that some health issues are more affected by changes in the urban environment than others.

Practice and Policy Implications/Recommendations

The connections between urban design and the risk factors and outcomes of non-communicable diseases should help guide future planning and policy decisions. The City Vision tool will help urban planners, health officials, the public, NGOs, and researchers estimate how changes to city layouts could affect the burden of NCDs in towns and cities across the UK. The project's findings will become available through the City Vision online platform, making it easier for people to access and use the information to support action.

Pathway to Impact

The primary beneficiaries of this research are those involved in urban design, planning, and public health systems—especially those who manage the costs and health issues linked to poorly designed cities. By gaining a deeper understanding of how urban design can help prevent non-communicable diseases, future programs could better use urban planning to reduce risk factors and lower the incidence of these diseases in the population. This would result in significant public health improvements and cost savings in healthcare in both the UK and Australia. More broadly, the methods developed in this project could be used globally to improve public health. The findings will be shared with key stakeholders through the City Vision platform and ongoing partnerships with government agencies and municipal organizations.

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Relevant Logos

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