INTERACTION

INTERVENTION, RESEARCH, AND ACTION FOR CITIES AND INNOVATION

INTERACT SCALE-UP PROPOSAL FOR
CIHR DRAGON'S DEN COMPETITION
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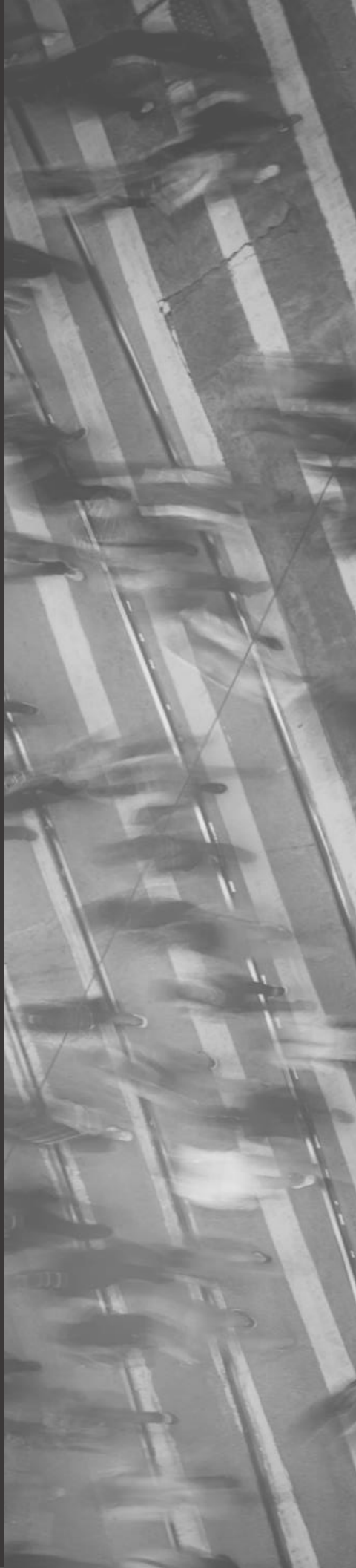

PROJECT DESCRIPTION

Massive investments in infrastructure and urban change projects planned by the federal and provincial governments and by municipalities will reshape Canada's cities for decades to come. Meanwhile, health care costs are skyrocketing. These investments are opportunities to create positive urban environments conducive to healthy living. Not only can they ease the pressure on health care costs, they represent concrete solutions to important societal issues with the potential for improving social integration, well-being, active participation, equity and leading to a more sustainable and just society. This is our blue sky idea: ***The INTErvention Research and Action for CiTies and InnOvatioN (INTERACTION) Program aims to develop concepts and methods to support a research and action agenda that will inform policy decisions and programs to create healthy, sustainable, and inclusive cities***!

To do so, we are building an interdisciplinary network of expertise in urban planning, public health, information technology, big data and artificial intelligence, and extending the INTErventions, Research, and Action in Cities Team (INTERACT, CIHR, 2016-2021) to ***offer a comprehensive framework and a combination of solutions to efficiently evaluate the impact of urban transformations on population health and equity***, while providing novel decision-making tools to guide future interventions.

Our vision builds on Jane Jacobs' heritage, wherein cities are 'an immense laboratory of trial and error, failure and success, in city building and city design' [1]. From that perspective, current and future built environment investments represent as many opportunities for natural experiments. With ***timely and well-designed data collection and analysis methods***, such natural experiments can ***generate robust evidence*** on ***how our transforming world can translate into improved health and greater equity***.

Already, INTERACT has deployed its intervention research platform in four Canadian cities, focusing on urban form impacts on physical activity, social participation and well-being. Studies are underway in Victoria, Vancouver, Saskatoon and Montreal. Various technological advances serve to optimise recruitment, data collection, and analyses, resorting to novel online tools, wearables and smartphone apps, pushing new algorithms and using artificial intelligence to transform big data into meaningful information, and using mixed-method approaches to capture collective thinking and actor networks dynamics. Today, INTERACT is ready to be scaled up: ***we propose an integrated comprehensive urban intervention research and action agenda across urban interventions, populations, and outcomes***.

In other words, the program adopts a systematic and complex system approach to intervention research, allowing the consideration of various types of urban interventions and exposures on one hand, and of various health outcomes on the other hand, adaptable to local realities and priorities. We are ready to extend our approach to target the top 25 cities of Canada, to analyse how large, medium and small cities are

experiencing change, how these impact health and equity, and to generate evidence guiding future decision making. To reach that goal, one crucial secondary output is a comprehensive series of tools and methods, specifically A) ***methods leveraging developments in information technology, big data and artificial intelligence to collect, transform and analyse data on urban vision, urban change and related population health trajectories***, and B) ***an evidence-based simulation tool to facilitate citizens', planners' and other decision makers' choices when designing future cities*** with health, equity, and sustainability goals. Overall, we believe this project has a strong fit with CIHR's 'strategic efforts to deepen Canada's scientific leadership in planning, designing and building healthy cities'.

Because our vision of urban transformation is comprehensive and inclusive, we are not identifying a 'specific intervention' per se – rather, we believe urban change is multifaceted, continuous, and might not be foreseen. The same is true for its consequences on health and equity in absence of strong evidence. Consequently, we aim to offer tools to capture continuous urban change and uncover its impacts: as the city evolves and grows, and populations interact with and adapt to these new conditions, efficient data collection tools can capture the complex interactions of environments and populations leading to health profiles. Appropriate algorithms and models can help identify the underlying processes and mechanisms, sort out causes and consequences, and further help identify future solutions.

The proposed program can be broken down into six related work packages (See Figure 1, Appendix). These work packages are partly based on the current organisation of INTERACT, while adding new features from lessons learned so far, including through identification of current gaps and future needs. Each of them can be described in terms of a) ***theoretical/conceptual underpinnings***, b) ***methods and tools***, partly existing and available, and partly to be developed, and c) ***processes and outputs***. We believe these six work packages offer a comprehensive solution for urban intervention research and action, specifically because it can be easily deployed in any city or setting to assess the impact of small or large, punctual or systematic, temporary or permanent, interventions. Depending on local needs, capacities, or ambitions, one can give more weight to one area or the other, but the true strength – and flexibility – of the framework is its integrated approach, from one to six. These six work packages naturally form a circular and whole process. Although one would start at 1, it is clear that work package 6 – share knowledge and simulate future interventions – feeds into 1 – the collective vision and organisational context that leads to future interventions.

For each of these work packages, we briefly describe the core conceptual underpinnings, the proposed methods, and processes, identify required

developments, and provide examples of application for urban intervention research and action.

1. *Understanding the broader policy and decision making context, cities' vision of the future*

Concepts: Cities are constantly shaped by micro, meso and macro decision making with both short and long term consequences. Transformative actions in the city are linked to people's vision of what the future should look like. In other words, people's vision of a 'desirable future state' is core to our understanding of urban dynamics and planning decisions affecting health and equity. Consequently, it is important to capture and document this 'concrete Utopia' that 'simultaneously anticipates and influences the future [2]. Certainly, conflicting visions exist, and are necessary ingredients of an active democracy, in which all should be able to participate. Some discourses, such as the goal for sustainability, have been largely adopted and offer a shared vision of the city of tomorrow while framing today's decision making. Capturing the collective vision is important to understand how society's conflicts, desires and decisions translate into the urban transformations we observe. By analysing the collective discourse and how involved actors relate, one also contributes to bridging conflicts and to a shared vision of the future. In other words, research is action. This first domain explores the basic values, principles and processes that govern the planning of healthy and equitable cities. Conceptual underpinnings call to notions of participatory visioning (a future), itself increasingly rooted within notions of sustainability and environmental justice which acknowledge the social and physical determinants of health and the power of transformative urban planning. ***Methods***: Adequate methods for this domain are discourse analysis, participatory planning, concept mapping, and actor network analysis. We will offer readily usable online tools and implementation guides to apply these methods. We have already successfully used online concept mapping, are currently developing actor network data collection tools and will share actor network analysis code. ***Outputs:*** These tools will for example allow the creation of concept maps representing stakeholder's and citizen's vision of urban interventions, pointing to key concepts relating to failure and success, while assessing importance and feasibility. Sub-group mapping can reveal diverging visions and goals, while fostering consensus. The actor networks will reveal how interventions – planned, ongoing or past – are linked to stakeholders' relations and dynamics, possibly pointing to network types or actor roles that foster success, in turn helping future planning and governance.

2. Identify and capture changes in urban environments

Concepts: Geographic Information Science is the core discipline for capturing and analysing data on geographic environments. Temporal GIS frames the triad of time, space, and objects to facilitate the capture, storage and analysis of multiple environmental features and their evolving status, from a space-time geography perspective [3]. Rapid technological developments are leading to the creation of a new spatially-rich data ecosystem, with inexpensive and miniaturised sensors becoming ubiquitous and part of the 'Internet of Things' allowing to track objects. Novel company- or citizen-generated spatial data provide information at an increasingly high spatial and temporal resolution. Examples of such datasets include Google Street View high-resolution street-level images, which can be observed retrospectively for urban feature identification using the Time-Machine function [4] satellite imagery, or built environment open data repositories increasingly provided by cities. This new 'big environmental data' reality calls for new data management methods, including automated processes ensuring archiving of historical data, and possibly capturing the 'space of flows' and movement defining the physical and social spaces of cities [5].
Methods: This research program will build upon an existing GIS infrastructure that already contains numerous snapshot datasets on environmental conditions, from land use and built environment features to satellite images and air quality. It will systematise the data collection on environments by connecting to open data repositories providing continuous information on urban change (e.g. monitoring cycling lanes, tree canopies, or traffic calming features). It will also facilitate the connection to environmental data available through the CANUE initiative (www.canue.org) in which several of our investigators take part. Spatio-temporal scripts will then facilitate linkage between environmental measures and populations (see below). *Outputs:* This infrastructure will provide the necessary data to track urban change, a prerequisite to further assess impacts on health and equity. We envision developing an urban environment exposure matrix that will list urban features potentially associated with a series of health outcomes. Using this matrix will help identify relevant environmental variables based on health outcomes under scrutiny, target populations, and research questions.

3. Capture individual and community health and equity

Concepts: Through their daily interaction with their environments, people are exposed to opportunities and risk conditions that influence their health behaviour and outcomes. Capturing the distribution of health and its evolution through time is important to be able to assess the impact of exposure to various environmental conditions, and to document rising or shrinking socio-spatial health inequality. Daily

mobility, social structure, and a life-course perspective need to be accounted for, as exposures occur through socio-spatial interactions that evolve through time. Community-level health measures further point towards collective processes and lifestyles [6] that contribute to individual and population health profiles and inequities, including through gentrification. ***Methods***: To capture individual and community health, we rely on a combination of approaches, including a) 'classic' online health questionnaires, that include questions on neighbourhood perception and interventions, b) interactive map-based questionnaires to identify activity spaces and social network structures[7], c) smartphone sensing to document daily mobility (GPS) and physical activity (accelerometer), d) Ecological Momentary Assessment for intra-day evaluation of well-being or environmental perception, and e) use of dedicated wearable sensors (e.g. sociometry), or environmental sensors (e.g. noise). A series of diversified recruitment methods facilitate quick setup of cohorts while limiting sampling bias. ***Outputs***: In collaboration with partner spin-off companies offering online (Polygon.company) and smartphone (Ethica Data) data collection tools , we will develop a comprehensive online sensing platform for a) efficient recruitment of participants to constitute cohorts, and b) rapid deployment of online questionnaires, smartphone and wearable sensing to capture population's health, social network structure, environmental perception, and behaviour. Complementary biometric, biomarker and genetic data collection will also be proposed, and integrated with smartphone apps for increased compliance [8].

4. Transform data into meaningful indicators

Concepts: Various adaptations of the socio-ecological framework provide a basis for hypothesised links between exposure to built environment conditions and urban interventions and daily mobility, social interactions, physical activity, or other health outcomes. In a context of rapid technological change and increasing amounts of available high-volume high-velocity data, indicators of interest should be able to combine high-resolution individual-level measures with 'just in time' spatial exposure measures. This rapidly evolving field of exposomics increasingly involves computer science expertise, in order to handle and link big data and to extract meaningful indicators [9]. For example, 1-second resolution GPS data may provide millions of coordinates describing a cohort participant's mobility, yet efficient algorithms are needed to identify relevant indicators, such as activity locations, trips, transportation modes, or time spent within certain environmental contexts. *Thinking* about such indicators requires conceptual frameworks that provide guidance about the underlying hypothesised mechanisms linking environments to health. *Constructing* such indicators further requires analytical capabilities to extract meaningful features from combinations

of big data sets. **Methods**: Various algorithms will be offered to transform environmental data into useful urban change indicators (e.g. machine learning image treatment algorithms to extract traffic calming interventions from Google Street View images), and to extract individual-level behavioural and exposure metrics (e.g. activity locations or travel mode detection from GPS tracks or amounts of PA per land use type when combining GPS and accelerometers). Our team includes advanced expertise in such data treatment procedures mostly based on machine learning and classification techniques. **Output**: The program will implement and publicly share all code base of machine learning and classification techniques for efficient and consistent transformation of big data on individual behaviour and environments for urban intervention research.

5. Generate evidence on interventions, health and equity

Concepts: Solid conceptual frameworks are needed to guide the modelling of hypothesised pathways between exposure to environments and health outcomes and equity. Such frameworks may be broad in their scope (e.g. socio-ecological perspectives), population-specific (e.g. environmental influences on healthy aging) or disease specific (e.g. PA opportunities and food environment influences on cardiometabolic risk). However, whereas they are often laid out from a static perspective, our intervention research perspective implies a focus on the dynamic process of urban transformation and the related change in behaviour and health. Because of this, socio-spatial dynamics are particularly of interest, and temporal modelling is key from a natural experiment perspective, both to assess positive impact but also, possibly, unintended negative consequences. **Methods**: Several statistical methods are adapted to the evaluation of urban change impact, including regression discontinuity, difference in differences or interrupted time series. Our datasets include a relatively large numbers of participants (e.g. online cohort recruitment) and a large number of data points (e.g. time-series of changing environments and behaviour, repeated intra-day measures, mobility and PA datapoints). This means we will most often have high statistical power, allowing relatively complex modelling accounting for multilevel interactions. Quantitative results will pave the way for complementary qualitative analysis, to further increase our understanding of perceptions and underlying processes linking environments to health and equity [10]. **Outputs**: The team will arrange for online repositories of all statistical scripts in R format to be used by the research community, and to increase comparability between cities and studies. All results will be published in open access international peer-reviewed journals.

6. Share knowledge and simulate future interventions

Concepts: Our program is guided by a framework for sustained impact, favoring early and sustained engagement with non-government organizations and policy makers nationally and locally. This is why our program has been developed in close collaboration with local and regional decision makers in the four INTERACT cities, with an important goal to share knowledge and develop decision-making aid tools. **Methods**: From a governance perspective, the proposed knowledge mobilization implies that decision makers and community organisations that are active in the studied territory are partners in the elaboration of the local cohort/study, contributing to the framing of the research questions, identification of interventions of interest, and active in the recruitment and targeting of relevant research questions. A knowledge broker has the specific role to develop and support such activities, which include online webinars, concept-mapping sessions, and eventually setting up partner advisory committees to guide the research process. Using the evidence that will be generated through this project and complementing it with other similar study outputs, we will further generate a Healthy City Simulation Platform that will allow to evaluate investment and intervention scenarios in terms of health and equity impact. **Outputs**: The team will generate various tools and processes to engage local and regional organisations in the research agenda. The Simulation Platform represents a key tool for decision makers' capacity to evaluate how planned investments will translate – or not – into healthier and more equitable cities.

In summary, INTERACTION offers a comprehensive set of conceptual underpinnings, tools and methods that will facilitate the systematic evaluation of large-scale population interventions across Canadian cities. Implementing such an infrastructure - currently lacking - can have an important positive and long term impact on population health and equity, by helping society and decision makers create environments that will not only support healthy living, but also social interaction, and sustainability. We will scale-up, i.e. extend and systematise the procedures already in place, to offer an integrated intervention research infrastructure for citizens, community groups, decision makers and researchers, facilitating the assessment and understanding of how urban interventions contribute to healthy and equitable cities. We propose that funding for this infrastructure be secured by a Healthy City Impact Assessment Fund, combining funding from CIHR, Infrastructure Canada (0.01% of all urban investments), Public Health Agency of Canada, and other possible provincial and municipal organisations. It will also receive in-kind contributions from partnering companies that will develop the online and wearable data collection tools, and simulation environments. Cities will pay minor fees for using the platform, knowing it will a) help them monitor their sustainability and equity targets, b) facilitate participatory planning and visioning, and

c) optimise resource allocation. Within each work package, a step-by-step evaluation of advancement of a) conceptual underpinnings, b) methods, and c) outputs will frame the evaluation of progress. Work package participants will have monthly online meetings to share progress and ensure work stays aligned with goals. INTERACT has already experience in work package structure and monitoring, using platforms like Slack for daily interactions.

We are a growing network of dedicated researchers and municipal, regional, provincial, and national decision makers interested in shaping tomorrow's agenda for healthy, equitable and sustainable cities. Our proposed comprehensive research agenda will be a catalyzer for new intervention research initiatives, and foster new inter- and multi-disciplinary collaborations among researchers and knowledge users. We are ready.

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Figure 1 – Framework for INTErvention Research and Action for CiTies and InnOvatioN (INTERACTION) Program

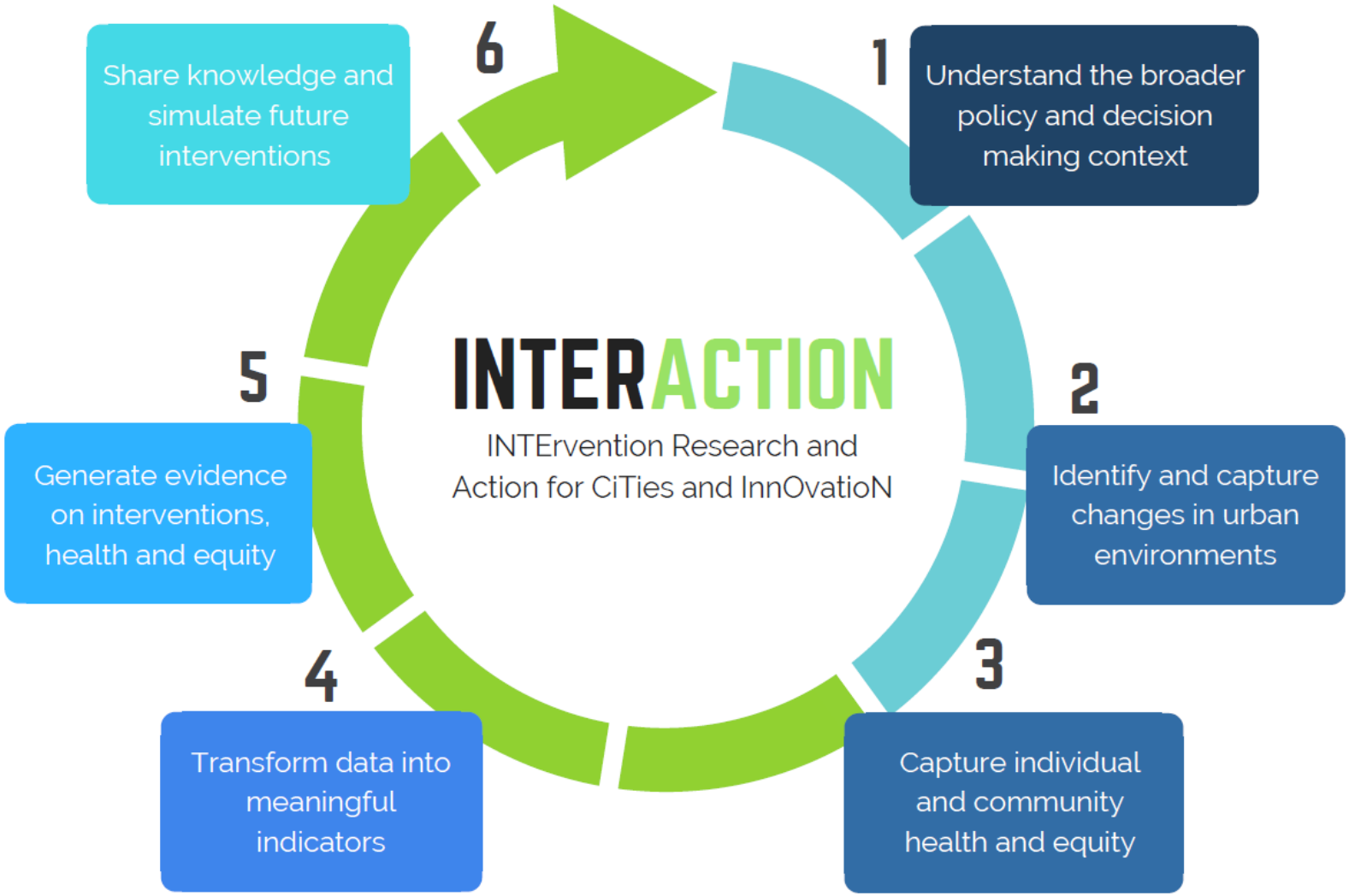

Table 1 – Key Concepts, Methods and Outputs for each INTERACT Work Package

		CORE CONCEPTS	METHODS		MAIN OUTPUTS	
		Core	Key	Gaps	Existing	Goal
1	**Understanding the broader policy and decision making context, the vision for the future**	Sustainability discourse and visioning - Urban Planning and Public Health - Actor Network Theory and Urban Planning - Participatory Planning / Intervention Building	Concept mapping - Discourse Analysis - Actor network analysis methods	Integrated online toolset for analysis of vision and decision making context for use in urban intervention research and action.	Collective and sub-group visions of the future city (concept mapping procedure, identification of core themes and objectives)	Online toolset for vision and actor network data collection, Concept map summarising visions, goals and gaps
2	**Capture changes in urban environments**	Geographic Information Science - Planning Theory - Multi-level multi-scale perspective	Geographic Information Systems - Remote Sensing - Distributed environmental sensors - Google Street View Time Machine - CANUE dataset	Automated extraction and regular backup of open-data on urban environments - Machine-learning methods for automatic detection of urban change based on remote sensing / street view image analysis - Intervention map-based questionnaire	Temporal GIS with various layers of information on social and physical environments - procedures (Python) for temporal environmental change extraction - Environmental sensor data	Online map-based questionnaire for intervention data collection - online data dictionary with environmental measures (Maelstrom Research)

3	**Capture individual and community behaviour**	Environmental determinants of health - Space-time geography - Mobility and exposure - Environmental psychology - Lifecourse perspective - Collective lifestyles	Online questionnaires - Map-based data collection - Wearables/smartphone tracking - Ecological Momentary Assessment	Offering a comprehensive online and wearable toolset for systematic tracking of health behaviour and outcomes and rapid setup, recruitment and follow-up of cohorts - just-in-time measures including EMA	Daily mobility tracking from GPS - Physical activity and sedentary assessment from accelerometers	Improve sociometric measures for within-day social interactions - Improve citizen-science participation - Improve recruitment and representativity of all populations
4	**Transform data into meaningful indicators**	Activity space indicators - Exposomics - Algorithms for GPS or for behaviour detection	Various algorithms with focus on spatial and temporal dimensions - Machine Learning - classification	Advanced individual exposure metrics accounting for activity space and temporal variations in environmental exposure - Big data exposomics	Detailed information on daily mobility including activity locations, trips, transportation modes - Localised PA estimates, total and by intensity level - Localised within-day variations in mood and affect (EMA) - Linkage between environmental	Improve just-in-time exposure measures - Improve GPS and accelerometry data transformation for identification of transportation modes and activity types

					exposure and detailed individual location history	

5	**Generate evidence on interventions, health and equity**	Natural experiment modelling - Socio-ecological perspective - Socio-spatial dynamics, temporal modelling	Regression discontinuity - Difference in Difference - Interrupted time series - Structural equation models - Qualitative assessment of the urban experience	Need to address daily mobility selection bias in exposure-outcome assessment – Need for better inclusion of unintended consequences	Models identifying associations, longitudinal analyses for improved causality assessment	Systematize analytic processes using environmental and individual big data set for rapid turnaround - Improve modelling capabilities for complex system analysis
6	**Share knowledge and simulate future interventions**	Collaborative research and action agenda - Framework for sustained impact - Decision making support	Concept mapping consultation - Partner advisory committees - Online Webinars	Accessible simulation tools based on (local) evidence	Scientific publications - Flash reviews published on INTERACT website - Concept maps shared with communities	Online simulation tool to design the future city with evaluation of health and equity impacts