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Smart prevention: A new approach to primary and secondary cancer prevention in smart and connected communities

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ABSTRACT

Smart and connected communities (SCC) describe the shift in urbanism towards technological solutions and the production of knowledge-based industries. Local governments are recognizing the opportunity of this paradigm shift to improve services, create more efficient policies, and increase the wellbeing of their citizens. These new tools create the possibility for local governments to respond differently to "wicked problems" facing cities, including increasing chronic disease prevalence. Using lung and skin cancers as case studies, we present *smart prevention* as a novel approach that uses smart city-enabled built environment monitoring to trigger local cancer-prevention policies. First, we present results of a scoping review we conducted to describe mechanisms by which features in urban built and social environments are hypothesized to contribute to lung cancer and skin cancer. We systematically searched fourteen electronic databases, yielding 47 articles that examined associations between built and social environment features and lung cancer (n = 34), and/or built and social environment features and skin cancer (n = 13). Second, we present a narrative review of smart city theory and governance. Third, we use findings from both reviews to draw conceptual links between cancer prevention and SCC – presenting a hypothetical suite of built environment and policy interventions to prevent lung and skin cancer.

1. Background

The concept of smart and connected communities (SCC) encompasses varying definitions of smart cities, digital cities, and connected cities discussed in the literature. The SCC vision has become reality in some cities, which are beginning to implement examples of these complex systems-level innovations (Dameri & Rosenthal-Sabroux, 2014). Smart and connected approaches to urban spaces present an opportunity to address 'wicked problems' – complex, multifactorial problems that are difficult to solve (Rittel & Webber, 1973) - facing the globe's communities. The growing burden of chronic illness and disease in industrialized nations has been characterized as a 'wicked problem' (Wheeler, 2013). Across the globe, non-communicable diseases (NCDs) are becoming increasingly prevalent, burdening healthcare systems and lowering economic productivity (Global Burden of Disease Study 2013 Collaborators, 2015). Cancer comprises a substantial proportion of this disease burden, with an estimated 17.5 million cancer cases and 8.7 million cancer deaths in 2015, and this number expected to increase in the future given current epidemiological and demographic trajectories (Fitzmaurice et al., 2017). Importantly, half of cancers are preventable through behavioural or environmental modifications (Vineis & Wild, 2014). These environmental modifications have potential to change community structures in a way that promotes cancer prevention behaviours.

The link between environmental factors and health has been well documented (Frumkin, Wendel, Abrams, & Malizia, 2011; Yen & Kaplan, 1998; Yen & Syme, 1999). The social ecological theory seeks to explain inter-connections between human health and determinants at various levels (Golden & Earp, 2012; Mcleroy & Bibeau, 1988). Briefly, humans are understood to be embedded within contexts that influence their behaviours and health outcomes, including the intrapersonal level (e.g., health knowledge and skills), the interpersonal level (e.g., health behaviour within social networks), the institutional level (e.g., institutional health policies), the community level (e.g., health-related attributes of a community's physical environment), and the policy level (e.g., broad-scale policies that impact health). Importantly, factors that influence behaviours (determinants of health, which can be social, biological, physical or political in nature (World Health Organization, 2017)) are seen as interacting with other behavioural determinants within and between levels of the social ecological model.

Within this theoretical backdrop, built and social environments are important health promotion contexts given their role in spatially

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patterning (in)equitable access to resources, their ability to affect the distribution of disease risk, and the structuring of human behaviour (Diez Roux, 2001; Schneider, 2011; Wheeler, 2013). For cancer in particular, the Multilevel Biologic and Social Integrative Construct framework has been proposed as an extension of the general socio-ecological model that identifies environmental and psychosocial contexts as a significant determinants of cancer at the macro-environmental, individual, and microbiologic levels of human physiology (Lynch & Rebbeck, 2013). A recent systematic review confirmed this relationship, suggesting the built environment can indeed affect cancer risk, incidence, treatment results, survivorship experiences, and survival outcomes (Gomez et al., 2015). The planning profession's ability to influence the built environment (Collison, 1954) presents a unique opportunity to deploy SCC enabled interventions to prevent cancer using real-time data. Given the substantial and growing global burden of cancer, that half of all cancers can be prevented, that over half the world's population lives in cities (United Nations, 2014), and that SCCs are advancing closer to the dominant reality, the objective of this paper is to examine how technological advances can be used in urban cancer prevention. We use lung and skin cancer as case studies to present a novel approach to cancer prevention in cities – *smart prevention*.

There are three forms of cancer prevention: (1) primary prevention, which aims to prevent the onset of disease by altering cancer risk behaviours (e.g., tobacco smoking) and contexts (e.g., high levels of air pollution) (2) secondary prevention, which encompasses screening and early diagnosis to slow or stop cancer progression; and, (3) tertiary prevention, which aims to prevent recurrence or progression of established cancers (Gordon, 1983; Roberts, 1954). The built environment can contribute to *primary* prevention through reducing exposures to risk factors for cancer (Gomez et al., 2015). Major risk factors for cancer include poor air quality, alcohol use, tobacco use, physical activity, diet, and ultraviolet radiation (UVR) exposure (Institute of Medicine and National Research Council, 2003). *Secondary* prevention can also be influenced by the built environment, specifically through the spatial distribution of healthcare and cancer screening resources in a community (Neutens, 2015; Zenk, Tarlov, & Sun, 2006). Given that typical approaches to tertiary cancer prevention include medical interventions (i.e., chemotherapy, radiation treatment, and surgery), we focus on primary and secondary prevention of cancer, and consider tertiary prevention out of scope for the current review.

This paper proceeds in three parts. First, we summarize the results from a scoping review that examines how researchers from diverse disciplinary backgrounds conceptualize associations between built and social environment features and lung and skin cancer prevalence or incidence, as well as hypothesized mechanisms underlying these associations. Second, we conduct a narrative review of the literature that seeks to define SCC, advancing the literature to encompass primary and secondary cancer prevention. Third, we use these findings to propose several SCC-enabled built environment interventions to reduce the population-level risks of lung and skin cancer, which we term as *smart prevention* based interventions.

2. Scoping review

A scoping review is a form of literature synthesis that follows a systematic protocol to investigate potential relationships between two concepts (Arksey & O'Malley, 2005; Colquhoun et al., 2014) without seeking to comprehensively identify or quantify all potential literature on the subject (Daudt, van Mossel, & Scott, 2013). Our scoping review encompasses four distinct fields of research: (1) cancer epidemiology and control, (2) urban planning and other built environment professions, (3) human geography, and (4) public administration and policy. We conducted a scoping (rather than systematic) review given our interest in *how* environmental exposures, outcomes, and covariates have been operationalized by these various disciplines, and disciplinary perspectives on the underlying conceptual mechanisms by which features of the built and social environment are associated with lung and skin cancer. Therefore, our review did not seek to explicitly quantify associations between built environment features and cancer risk, but rather to demonstrate how this multidisciplinary research question has been discussed to date.

2.1. Methods

This review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines in the description of the methods (Samaan et al., 2013). We adopt a scoping review methodology to the methods, following established guidance on the conduct of these reviews (Colquhoun et al., 2014; Levac, Colquhoun, & O'Brien, 2010). This section details the methods of the larger scoping review (which sought to examine environmental determinants of all cancers). The results section describes a subset of the total included records that focus exclusively on lung and skin cancer sites.

2.2. Search strategy

We searched fourteen databases: ABI/INFORM, CINAHL, Cochrane Library, EMBASE, ERIC, ESPM, Google Scholar, HeinOnline, JSTOR, LexisNexus, Medline, Scopus, and Web of Science for peer-reviewed journal articles published in English from January 1990 to April 2017. The search strategy consisted of combining terms that represented the built environment, the urban planning profession, and cancer using AND and OR Boolean operators to search titles, abstracts and keywords. Thus, *built environment* themed terms are combined with an OR operator

Table 1
List of search terms by theme.

Theme	Search terms
Built environment	"Built environment" OR "obesogenic environment" OR "urban form" OR neighbourhood OR "neighbourhood development" OR neighbourhood OR "neighbourhood development" OR "built form" OR "food environment" OR "food access" OR "urban design" OR architecture OR "traditional neighbourhood design" OR "traditional neighbourhood design" OR "healthy built environment" OR "healthy communities" OR "healthy places" OR "public space" OR sidewalk* OR park OR "green space" OR greenspace OR "green corridor" OR greenway OR "rail-trail" OR "open space" OR "community garden" OR albedo OR "LEED-ND" OR street* OR road* OR highway OR freeway OR walkability OR "transportation infrastructure" OR "transportation network" OR "public transit" OR "light rail" OR bus OR streetcar OR tram OR subway OR metro OR pedestrian OR ((bicycle OR cycle OR bike) AND (infrastructure OR lane*))
Cancer	Cancer OR neoplasm*
Risk factors	Vegetable* OR fruit* OR nutrition OR diet* OR "food consumption" OR smoking OR cigarette* OR tobacco OR "thermal stress" OR airshed OR "particulate matter" OR "PM 2.5" OR "air pollution" OR "air quality" OR "air pollutants" OR drinking OR alcohol OR walking OR "active transportation" OR "physical activity" OR exercise OR sedentary OR biking OR "active living" OR "ultraviolet radiation" OR UV OR tanning OR "sun exposure" OR UVR OR "light exposure"
Policy	((Local OR municipal OR regional OR urban OR rural OR town OR community) AND (bylaw* OR law* OR legislation OR policy))
Planning	(Zoning OR bylaw OR "urban policy" OR "municipal policy" OR "local policy" OR "official plan" OR "community plan" OR "secondary plan" OR "district plan" OR "urban planning" OR "rural planning" OR "town planning" OR "regional planning" OR "city planning" OR "community planning" OR "land use planning" OR "development charge" OR "population-based planning" OR "new urbanism" OR "smart growth" OR "transit oriented development")