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Governing disruptive technologies for inclusive development in cities: A systematic literature review

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ABSTRACT

Cities are increasingly adopting advanced technologies to address complex challenges. Applying technologies such as information and communication technology, artificial intelligence, big data analytics, and autonomous systems in cities' design, planning, and management can cause disruptive changes in their social, economic, and environmental composition. Through a systematic literature review, this research develops a conceptual model linking (1) the dominant city labels relating to tech-driven urban development, (2) the characteristics and applications of disruptive technologies, and (3) the current understanding of inclusive urban development. We extend the discussion by identifying and incorporating the motivations behind adopting disruptive technologies and the challenges they present to inclusive development. We find that inclusive development in tech-driven cities can be realised if governments develop suitable adaptive regulatory frameworks for involving technology companies, build policy capacity, and adopt more adaptive models of governance. We also stress the importance of acknowledging the influence of digital literacy and smart citizenship, and exploring other dimensions of inclusivity, for governing disruptive technologies in inclusive smart cities.

1. Introduction

The increase in complex challenges, coupled with a high rate of urbanisation, has led cities to embrace technology to achieve their sustainability goals (Batty et al., 2012; Kitchin, 2014; Bibri and Krogstie, 2017a). Cities rely on information and communication technology (ICT) and data sensing (Kramers et al., 2014; Bifulco et al., 2016; Bibri and Krogstie, 2017b), Internet of Things (IoT) and big data (Schaffers et al., 2011; Perera et al., 2014; Bibri, 2018), and smart sensors and data processing combined with artificial intelligence (AI) (Allam and Dhunny, 2019; Yigitcanlar et al., 2020a; Yigitcanlar and Cugurullo, 2020; Yigitcanlar et al., 2020b) to design and implement services, monitor the use of resources, and encourage participation. Additionally, the adoption of technology-based urban models, such as smart cities, can help governments achieve the Sustainable Development Goals (Leal Filho et al., 2022). Given the lasting effects of the Covid-19 pandemic on urban development, the adoption of advanced technologies is also set to increase, with surveillance systems, autonomous systems and robots being used to monitor and manage different municipal services (Allam and Jones, 2021; Shorfuzzaman et al., 2021). These technologies are often disruptive in nature, having the potential to cause major upheavals in resource-challenged urban environments (Herrera-Quintero et al., 2019; Radu, 2020; Taeihagh et al., 2021; Choi et al., 2022). In this contribution, given their characteristics, we use the terms 'advanced technologies' and 'disruptive technologies' interchangeably.

The use of technology as a driving force in cities is linked with several labels, including sustainable cities, smart cities, digital cities, intelligent cities, eco-cities, and resilient cities (Harrison et al., 2010; Joss, 2010; Komninos, 2011; Albino et al., 2015; Hollands, 2015; Ahvenniemi et al., 2017; Bibri and Krogstie, 2017a; Tan and Taeihagh, 2020; Li et al., 2022). In this technology-driven urban environment, inclusive development in cities is increasingly important, as poor policy decisions in managing advanced technologies can lead to the exclusion of large sections of society from accessing and utilising the benefits associated with adopting such technologies. Additionally, targeting inclusive development calls for acute – and more involved – regulatory

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Table 1
Keywords and associated concepts for cities, technology, and inclusivity.

Concepts	Keywords
Cities	smart city(s), smart city development
	intelligent city(s), information city(s), knowledge city(s), digital city(s), IT city(s), IT-city(s)
	sustainable city(s), resilient city(s), liveable city(s), eco-city(s), eco city(s), green city(s), low carbon city(s), low-carbon city(s), creative city(s)
	global city(s), global city region(s), mega-city(s), mega city(s), mega-city regions(s), mega city regions(s), world city(s), world-class city(s), world class city(s), alpha city(s)
	Network(ed) city(s), corporate city(s), ubiquitous city(s)
	city region(s), metropolitan region(s), urbanisation, urbanisation
Technology	Technology(s), advanced technology(s), disruptive technology(s), novel technology(s), state-of-the-art technology(s), state of the art technology(s), cutting edge technology(s), cutting-edge technology(s), breakthrough technology(s), information technology(s), emerging technology(s), innovation, innovative, high-tech, high tech, big-tech, big tech, big data, data-driven, data driven
	IT platform(s), IT-platform(s), digital platform(s), IoT, internet of things, internet-of-things, AI, artificial intelligence
	automated system(s), intelligent system(s), smart system(s), autonomous system(s), robotic system(s), socio technical system(s), socio-technical system(s), e-governance
	advanced engineering, advanced infrastructure, digital infrastructure, modernization, informatics, transition(s), transformation(s)
Inclusivity	inclusion, inclusivity, inclusive development, sustainable, sustainability, sustainable development
	equality, equitable, equity, integration, accessible, accessibility, neutral, neutrality, uniformity, impartial, impartiality, ethical, transparency, accountability, opacity, responsible, responsibility
	Digital divide, polarisation, polarisation, bias, biased, biasness, partiality, stratification, fragmentation, disparity, inequality, discrimination, discriminatory, marginal, marginalised, marginalisation

and financial interventions from governments, particularly in regard to the private sector (de Jong, 2021). Previous studies of inclusive development in cities (or inclusive cities) have focused on its composite dimensions (Liang et al., 2021), avenues for marginalised populations to access land rights, access to economic growth opportunities, the role of social diversity in urban planning (Hanson, 2004; Ianchovichina and Lundstrom, 2009; Schreiber and Carius, 2016; Dahiya and Das, 2020; Tan and Taeihagh, 2020), and the conception of inclusive development within the New Urban Agenda and post-colonial urban studies (Bunnell, 2019). However, despite the importance of technology adoption for inclusive development in cities, there has thus far been a lack of systematic exploration connecting urban development, technology, and aspects of inclusion. In particular, further research is needed to understand the policy, regulatory, and institutional aspects of concern for inclusive development when cities pursue the adoption of disruptive technologies. Our research questions respond to the increasing importance being placed on inclusive development in technology-driven urban development. Not only do they focus on the different city labels associated with tech-driven urban development, they also elaborate on the different disruptive technologies applied in cities that are concerned with inclusive development.

We address the research gap summarised above by investigating the following questions: What are the dominant city categorisations or labels relating to the adoption of technology solutions? What are the different typologies and avenues of application of disruptive technologies in cities, that are relevant to inclusive development? What are the drivers of cities and their governments adopting disruptive technologies? What are the barriers they present towards inclusive urban development? We investigate these questions by establishing a framework that connects technology-driven urban development models with issues of inclusivity through identifying the drivers behind the adoption of such technologies and their impact on the inclusion of vulnerable groups. We first establish our preliminary framework based on our research questions and an overview of the theoretical landscape. This framework establishes an initial connection between the key elements of our research: cities, advanced technologies, and inclusive development. The framework is then developed iteratively as we incorporate the results from our systematic review, including the drivers behind cities adopting advanced technologies and the barriers these technologies present in regard to inclusive development. The conceptual framework also allows us to structure and organise the findings from our analysis.

Section 2 describes the literature selection and shortlisting process. Section 3 investigates the intersection of different city labels, disruptive technologies, and inclusive development. Here we propose an outline of our theoretical framework. Sections 4 and 5 discuss the motivations behind adopting disruptive technologies, and the barriers these technologies present to inclusivity. In Section 6, we examine the policy implications, and the measures cities can take to ensure inclusivity while adopting advanced technologies. Section 7 concludes.

2. Methodology

The search strategy consists of relevant keywords associated with technology, various city labels, and inclusive development (Table 1). We select studies based on their recognisability, resonance, and acceptance in academic literature and wider policy discourse, with several shortlisted from previous studies by De Jong et al. (2015) and Tan and Taeihagh (2020).

Before we analyse the connections between urban development and technology adoption and inclusive development, we must discuss the use of city labels in the selected studies. Using city labels to identify urban development models allows us to systematically identify and analyse the relevant literature. Previous studies have also acknowledged that city labels not only show conceptual differences amongst themselves within academic discussions, but also have a wider practical significance in policy design (De Jong et al., 2015; Fu and Zhang, 2017; Schraven et al., 2021). Several other bibliometric studies also follow suit, investigating the distribution and related significance associated with different city labels (De Jong et al., 2015; Min et al., 2019; Wang et al., 2019; Zhao et al., 2019; Janik et al., 2020; Pérez et al., 2020). Other studies have discussed the role of city labels in driving a corporate model of urban development and being used as a branding tool to drive certain strategic programmes (Söderström et al., 2014; Hollands, 2015; De Jong et al., 2018). Although the incorporation of technologies is usually associated with smart cities, digital cities, or intelligent cities, we expand the terms to include broader terms, such as green city, eco-city,

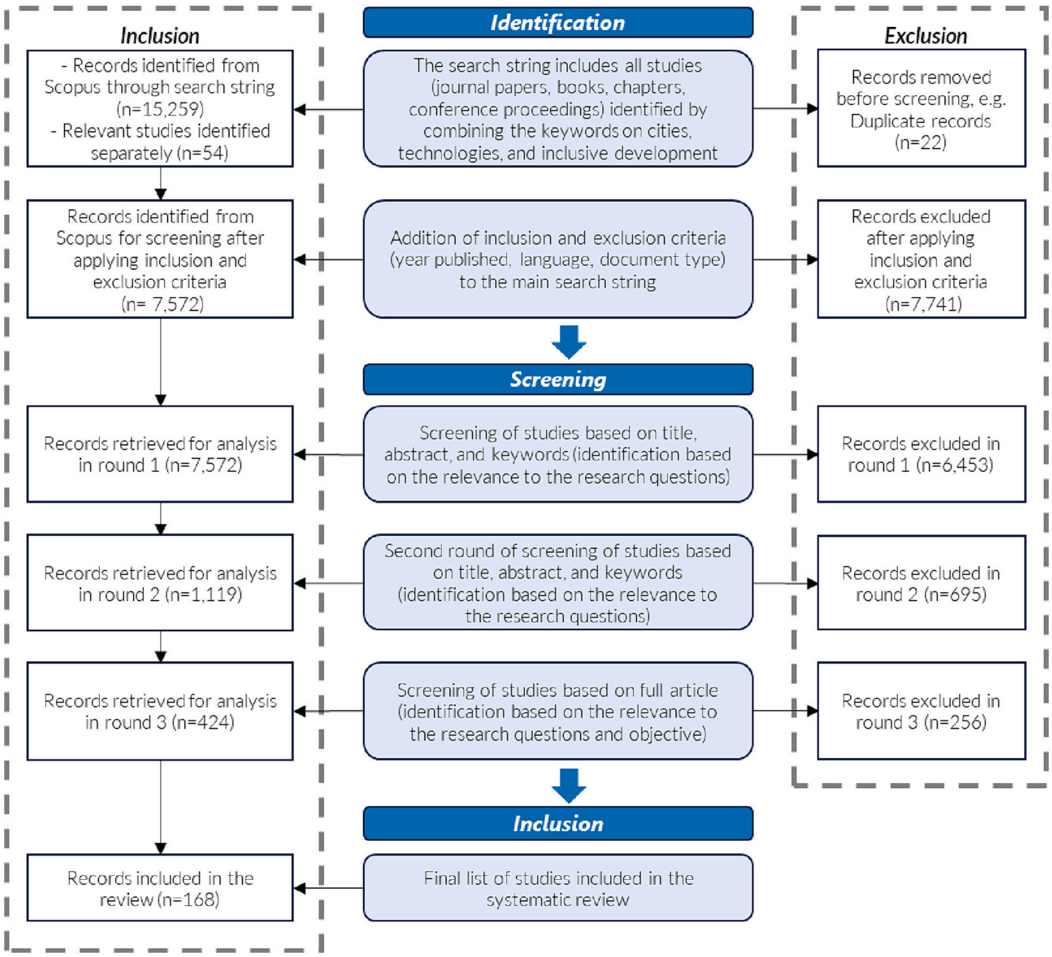

Fig. 1. PRISMA chart for systematic selection of literature.[a]
[a]PRISMA flowchart template derived from http://prisma-statement.org/PRISMAStatement/FlowDiagram.

ubiquitous eco-city, mega city, and low-carbon city, amongst others, to ensure a comprehensive search. Certain terms, such as mega city(s) and world city(s), may not appear to have a direct relevance to our research questions. However, several studies discuss their connection to using advanced technologies to resolve their urban challenges (Wall and Stavropoulos, 2016; Vleugel and Bal, 2017; Visvizi and Lytras, 2018), leading to their inclusion in our search string. Additionally, our short-listed terms are often used interchangeably by policy makers and in academic literature, showing evidence of 'terminological fuzziness' (De Jong et al., 2015). Our study seeks to avoid the possible exclusion of urban development models related to technology adoption and inclusive development. The terms associated with technology target a broad set of innovations that have direct or indirect implications for the infrastructure, planning, management and governance of the urban environment. By using keywords relating to specific technologies, such as ICT, sensors, and IoT, amongst others, and using broader terminology to describe technology, we are able expand our search strategy to cover any and all advanced technologies associated with urban development. We include terms such as cutting edge, breakthrough, and state of the art, amongst others, as keywords to capture the disruptive nature of urban innovations. The keywords associated with inclusivity focus on the challenges associated with adopting technologies. We also incorporate concepts that are analogous to inclusivity, such as sustainability, equality, transparency, accessibility, participation, engagement, and polarisation, as these are connected directly with technology adoption in cities. We also do not restrict the concept of inclusivity to social inclusion and diversity, but rather extend it to include spatial, economic, and technological inclusion of either individuals or groups of individuals.

We executed the search query on 23 March 2022. Fig. 1 shows the 'Preferred Reporting Items for Systematic and Meta-Analyses chart' (Moher et al., 2009), documenting the various stages of the subsequent shortlisting based on several inclusion and exclusion criteria.

In the start of the identification process, we develop and run a search string combining the three sets of keywords using 'AND' and parentheses on Scopus, as it contains a larger range of peer-reviewed studies compared to other sources (Aksnes and Sivertsen, 2019). Our search identifies over 15,000 studies that are associated with cities, technologies, and inclusivity. We narrow down our search results by adding certain inclusion and exclusion criteria to the search string. First, we include only studies in English, to cover a wide canon of academic literature. We limit the search to literature produced from January 2009, as the dialogue on advanced technologies associated with urban development and smart cities has increased in prominence since 2009 (De Jong et al., 2015; Tan and Taeihagh, 2020; Schraven et al., 2021).

Table 2
Summary of shortlisted articles.

Total number of shortlisted articles	168 articles
Publication Date	01 January 2009–23 March 2022
Database	Scopus

Classification of shortlisted articles	Number of articles
Categories: Cities	57 (33.9 %)
Category: Technology	52 (30.9 %)
Category: Inclusivity	14 (8.3 %)
Shared categories (Cities & Technology)	25 (14.8 %)
Shared categories (Cities & Inclusivity)	14 (8.3 %)
Shared categories (Technology & Inclusivity)	6 (3.5 %)

Lastly, we include all articles and reviews published in peer-reviewed journals, including empirical studies, qualitative and quantitative case studies, policy design, and evaluation studies. Our now updated search string[1] in combination with adding relevant articles, results in 7572 retrieved records.

Our screening process consists of multiple subsequent rounds. The first round, in which the records are screen by reviewing their title, abstract, and keywords is based on their relevance to our research objectives and questions. Subsequently, based on discussions between the first and second author, we conduct a second round of screening of the title, abstract, and keywords. In the final round, we screen 424 articles, based on their relevance to our research questions. Based on our screening process, the total number of studies included in our final analysis is 168 (additional details on the shortlisted studies are provided in Supplementary Table B). We also observe the publication trend of our selected articles, with the highest number of articles published in 2019 and 2020. Our shortlisted studies are from interdisciplinary journals, such as *Sustainable Cities and Society*, *Technological Forecasting and Social Change*, *Journal of Urban Technology*, *Sustainability*, and *Cities*, amongst others. We also observe the prevalence of using case studies and conceptual studies as primary methods for investigation, spanning a wide geographical range. Further details on the distribution of the shortlisted studies are available in Supplementary Fig. A (1–6).

We categorise articles based on the following discussion points: (1) characteristics of city categories, (2) use of advanced technologies, and (3) characteristics of inclusive development (listed in Table 2). We also take into consideration that certain articles may cover multiple discussion points, and we categorise them accordingly (Table 2). Our analysis is based on a thematic synthesis of the shortlisted articles, where we identify relevant sections that correspond to the above discussion points and our research questions on the drivers behind technology adoption in cities and the barriers to inclusive development. This approach combines the advantages of both deductive and inductive approaches, allowing us to draw on results from earlier studies and extract newer elements from recent studies (Thomas and Harden, 2008). We also assess the quality of the studies based on the reporting standards and quality of each study's objectives, methodology, and results, along with the appropriateness of the study methods (Fossey et al., 2002).

Explicit efforts have been made to be as comprehensive and consistent as possible, but this does not mean our systematic review has no limitations. The following limitations are noted: (a) the results do not include any findings from grey literature; (b) despite considering a wide range of keywords, certain relevant articles may still be excluded; and (c) the literature is coded thematically and is subject to the authors' biases in selection and interpretation. Despite these limitations, our analysis identifies the regulatory and policy implications from adopting advanced technologies for inclusive urban development.

3. Intersection of cities, disruptive technologies, and inclusivity

3.1. City labels

The dominant city labels that discuss technology-driven urban development include smart cities, intelligent cities, smart sustainable cities, eco-cities, and low-carbon cities. These labels are not interchangeable and have distinct identities, albeit with some overlap and interconnections (De Jong et al., 2015; Schraven et al., 2021). Amongst the various city labels, 'smart city' has eclipsed the previously common terms 'digital city' and 'information city' in usage and adoption (De Jong et al., 2015). Although we include a wide range of city labels and urban development models associated with technology adoption, our results indicate the dominance of the term smart cities in the academic and policy discourse. Nearly 60 % of the shortlisted articles directly engage with smart cities in some capacity (details in Supplementary Figs. A1-A6). Other bibliometric analysis covering city labels associated with economic growth, sustainable growth, and eco-modernisation also observe the popularity of the term smart cities in recent academic discourse (De Jong et al., 2015; Fu and Zhang, 2017; Schraven et al., 2021). It is therefore not surprising that most of our subsequent analysis of the drivers behind technology adoption and the barriers they present to inclusive development have a particular focus on smart cities. However, despite their prevalence in our systematic review, we do not limit our research questions to only smart city development. This allows us to capture a wider range of literature that delves into technology-driven urban development and its impact on aspects of inclusion.

The smart city has been used as a 'strategic device' in the uptake of ICT and other digital technologies in urban development (Caragliu et al., 2011; Kitchin, 2014). It is visualised as a complex system that includes humans, infrastructure, and process components, such as economy, governance, mobility, and the natural environment (Khatoun and Zeadally, 2016), and that can incite "multidimensional changes" to existing socio-technical systems (Mora et al., 2022). Other definitions of the smart city from the perspective of technology companies, such as IBM, include an 'instrumented, interconnected and intelligent city' (Harrison et al., 2010), which is reflected in the city's ability to integrate real-world data into a platform that connects the information to different service providers through the means of complex analytics, modelling, and visualisation. However, obtaining a clear and consistent definition remains elusive as there are several accepted understandings of smart cities (Schaffers et al., 2011; Mora et al., 2017; Chong et al., 2018;

[1] "TITLE-ABS-KEY ('smart cit*' OR 'intelligent cit*' OR 'information cit*' OR 'knowledge cit*' OR 'digital cit*' OR 'IT cit*' OR 'IT-cit*' OR 'sustainable cit*' OR 'resilient cit*' OR 'liveable cit*' OR 'livable cit*' OR 'eco-cit*' OR 'eco cit*' OR 'green cit*' OR 'low carbon cit*' OR 'low-carbon cit*' OR 'creative cit*' OR 'global cit*' OR 'mega-cit*' OR 'mega cit*' OR 'world cit*' OR 'world-class cit*' OR 'world class cit*' OR 'alpha cit*' OR 'network cit*' OR 'corporate cit*' OR 'ubiquitous cit*' OR 'city region*' OR 'metropolitan region*' OR 'urbanisation' OR 'urbanisation') AND TITLE-ABS-KEY ('technolog*' OR 'automated system*' OR 'intelligent system*' OR 'smart system*' OR 'autonomous system*' OR 'robotic system*' OR 'socio technical system*' OR 'socio-technical system*' OR 'e-governance' OR 'innovati*' OR 'hi-tech' OR 'high tech' OR 'big-tech' OR 'big tech' OR 'big data' OR 'data-driven' OR 'data driven' OR 'advanced engineering' OR 'advanced infrastructure' OR 'digital infrastructure' OR 'modernization' OR 'informatics' OR 'transition*' OR 'transformation*') AND TITLE-ABS-KEY ('inclusi*' OR 'sustainab*' OR 'equality' OR 'equitable' OR 'equity' OR 'integration' OR 'accessib*' OR 'neutral*' OR 'uniformity' OR 'impartial*' OR 'ethical' OR 'digital divide' OR 'polarisation' OR 'polarisation' OR 'bias*' OR 'partiality' OR 'stratification' OR 'fragmentation' OR 'disparity' OR 'inequality' OR 'discriminat*' OR 'marginal*') AND (LIMIT-TO (LANGUAGE, 'English')) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012) OR LIMIT-TO (PUBYEAR, 2011) OR LIMIT-TO (PUBYEAR, 2010) OR LIMIT-TO (PUBYEAR, 2009)) AND (LIMIT-TO (DOCTYPE, 'ar') OR LIMIT-TO (DOCTYPE, 're'))"

Yigitcanlar et al., 2018), which can be categorised into two broad sections. The first strand focuses on applying advanced technologies over a range of services and infrastructure (Schaffers et al., 2011; Al Nuaimi et al., 2015; Bifulco et al., 2016; Hashem et al., 2016; Ahvenniemi et al., 2017; Kummitha and Crutzen, 2017; Bibri, 2018; Allam and Dhunny, 2019; Sánchez-Corcuera et al., 2019; Sharma et al., 2019; van den Buuse and Kolk, 2019). This turn in the literature can be attributed to the rise of real-world user interfaces built on internet-based technologies, such as 'mobile devices, cloud computing, and the Internet of Things' (Schaffers et al., 2011). Here, ICT and other digital technologies aim to increase the quality of life and the efficient use of resources. The second strand emphasises developing human and social capital, along with digital solutions (Caragliu et al., 2011; Angelidou, 2015; Castelnovo et al., 2016; Meijer and Bolívar, 2016; Bouzguenda et al., 2019). Here, smart city frameworks apply a holistic approach to community building, public value generation, sustainability management, co-creation, and participatory approaches in governance (Gabrys, 2014; Castelnovo et al., 2016; Meijer and Bolívar, 2016).

Eco-cities, low-carbon cities, and smart sustainable cities also combine holistic characteristics with technological advancement. Despite beginning in social ecology and sustainable resource management, eco-cities utilise technology to achieve environmental sustainability goals (Joss, 2010; Joss and Molella, 2013; Yigitcanlar and Lee, 2014). Similar concepts include low-carbon city and ubiquitous eco-city: these types of city use embedded technology and computing to emphasise the impact of climate change, target a high quality of life, and achieve a nominal environmental impact (Yigitcanlar and Lee, 2014; De Jong et al., 2015; Mullins, 2017). Moving beyond smart cities, 'smart sustainable cities' build on environmental, social and economic sustainability (De Jong et al., 2015; Höjer and Wangel, 2015) by applying data-driven solutions to address complex and intractable challenges (Bibri and Krogstie, 2017a; Martin et al., 2018; Silva et al., 2018; Bibri, 2019; Bibri and Krogstie, 2019; Yigitcanlar et al., 2019a). Intelligent cities have also been discussed briefly in the context of technology adoption and inclusive development (Komninos, 2011; Deakin, 2012; Komninos and Tsarchopoulos, 2013). Although intelligent cities are conceptually similar to smart cities and smart sustainable cities, they focus more on embedding electronic and digital technologies, such as ICT, in cities, using these technologies to transform quality of life, and bringing ICT technologies and their users together to encourage innovation and learning opportunities (Komninos, 2011). Given our focus on technology-driven urban development, combined with inclusive development, it is not surprising that the labels digital city, network city, and intelligent city, which do not contextualise technology within society, unlike other labels, are not a dominant part of our systematic review.

3.2. Advanced technologies in urban development

Technology solutions, such as data collection systems (sensors, ICT, virtual and augmented reality), data intelligence (big data and AI), autonomous systems (e.g., vehicles, drones), and networking technologies (IoT, IT platforms), are a common feature within the different city labels. Increasingly, ICT-based sensing devices work inconspicuously in the background of the urban environment, collecting and processing data and mapping possible scenarios for the transport, energy, waste and water management, and healthcare sectors (Batty et al., 2012; Hancke and de Silva, 2013; Kitchin, 2014; Bibri and Krogstie, 2017b; Shorfuzzaman et al., 2021). The scale of data collection varies, from individual smartphone users (Kitchin, 2014; Bifulco et al., 2016) to digitally monitored and controlled utility services, sensors, and camera networks in CCTVs, building management systems and transport systems (GhaffarianHoseini et al., 2013; Kramers et al., 2014). Cities also apply VR technologies to systematically quantify urban features for planning purposes (Jamei et al., 2017; Zhang et al., 2019).

Sensing and data monitoring technologies that collect information in cities can be categorised into seven main components: 'surveillance, electricity and water distribution, buildings, healthcare, services, and transport' (Hancke and de Silva, 2013). Almost all of these services utilise sensors in some manner, i.e., as a convertor of physical sensors to an electronic signal, which is then fed into a computing system. ICT-based sensors are mainly used to monitor the use of public infrastructure, improve resource utilisation, and reduce maintenance costs via two-way communication and monitoring between the system providers, operators, and consumers (Hancke and de Silva, 2013; Loideain, 2017). Several aspects of mixed-use planning and transport planning now depend on context-aware applications that are run based on ICT applications (Bibri and Krogstie, 2017b). Other applications of ICT sensors include identifying hotspots of high energy usage for targeted measures to reduce energy consumption (Kramers et al., 2014). At the scale of the user, smartphone apps provide users with an avenue for community participation, as well as improved availability of information (Bifulco et al., 2016). Other research on ICT and environmental sustainability from a macro-economic level reveals that ICT can only contribute to a reduction in CO2 emissions once a certain threshold of technological development has been established (Añón Higón et al., 2017).

The use of ICT-based sensors generates an increased volume of structured and unstructured data. The collected urban data is characterised by its large volume, along with its complexity, heterogeneity, and volatility, and thus advanced storage and computational systems for analysing and processing this data are needed (Hashem et al., 2016; Bibri and Krogstie, 2017c; Marjani et al., 2017). Analysing this big data consists of prescriptive, diagnostic, and descriptive tasks, involving machine learning, database querying, data mining, and explanatory and predictive modelling (Bibri and Krogstie, 2017c). Big data is applied ins relation to electric vehicles and smart grids (Li et al., 2017), logistics (Hopkins and Hawking, 2018), managing carbon emissions (Giest, 2017), e-government, business, policymaking (Al Nuaimi et al., 2015; Hashem et al., 2016; Meijer and Bolívar, 2016; Löfgren and Webster, 2020), and real estate markets (Boeing et al., 2020). It is also processed by AI systems that imitate cognitive functions (Chan, 2020; Yigitcanlar et al., 2020a; Yigitcanlar and Cugurullo, 2020), enabling policymakers and planners to develop a better understanding of the complexities in cities (Allam and Dhunny, 2019). IoT and IT platforms help connect heterogenous ICT-based devices to a larger internet system through mobile crowdsensing and cyber-physical cloud computing (Schaffers et al., 2011; Perera et al., 2014; Zanella et al., 2014; Sun et al., 2016; Ge et al., 2018). In urban governance, IT platforms are tools that are used to manage information and stakeholder interaction (Anttiroiko et al., 2014; Lee et al., 2020a; Repette et al., 2021). Examples include IBM's 'smarter city project' (Junior et al., 2018) and Sidewalk Labs' proposal in Toronto (Carr and Hesse, 2020; Mann et al., 2020). Several studies focus on autonomous vehicles (AVs), smart mobility systems, and ride-sharing (Olaverri-Monreal, 2016; Crayton and Meier, 2017; Lim and Taeihagh, 2018; González-González et al., 2019; Lim and Taeihagh, 2019; Yigitcanlar et al., 2019b; Cugurullo et al., 2020; Nikitas et al., 2020; Icasiano and Taeihagh, 2021; Tan and Taeihagh, 2021). AVs utilise machine-learning algorithms to continuously learn new information and are expected to increase road safety, lower energy consumption, and free up road capacity (Olaverri-Monreal, 2016; Vleugel and Bal, 2017; Cohen and Cavoli, 2019; Lim and Taeihagh, 2019).

3.3. Inclusivity

Given the nature of technological advancement and urbanisation in cities, there is also corresponding literature discussing the role of inclusive urban development and inclusive cities. The World Bank breaks down inclusive development in cities into three key dimensions: spatial inclusion, which relates to providing citizens with housing, services, and access to infrastructure; social inclusion, where marginalised populations enjoy equal rights and participation; and economic inclusion, which allows for equal access to opportunities for economic growth (World Bank, 2020). Inclusion is also expanded to include political inclusion, where the citizen and the state share a 'rational and non-discriminatory relationship'; and environmental inclusion, which involves retaining natural resources for future generations (Liang et al., 2021). Although the different dimensions of inclusive cities are conceptually unique, they are considered to be synergistic in nature. Apart from the social, economic, and environmentally sustainable values desired by cities, newer aspects that target inclusive urban development are being considered when designing cities. These include sustainable mobility, the safety of residents, and liveability (González-González et al., 2019), along with participatory opportunities being given to stakeholders to create public value (Liang et al., 2021). Other related discussions on inclusivity expand it to include to social equity. Social equity is broken down into distributional, recognitional, and procedural dimensions, which covers providing equitable access to resources, understanding capacity differences across communities, and increasing the participation of all communities in decision-making processes, respectively (Meerow et al., 2019).

With cities adopting technology solutions, there is concern about inequitable distribution of resources, inaccessibility of certain digital services, and the lack of contextualisation of digital solutions within urban development. Evidence from the smart city programme in India suggests that several vulnerable sections of the population may be underserved when it comes to obtaining the benefits of high-quality ICT-led infrastructure (Praharaj, 2021). One particular concern is that the increased dependency of technology on the supply side, without incorporating social infrastructure, makes cities vulnerable to private interests (Söderström et al., 2014; Yigitcanlar and Lee, 2014), and it does not address the underlying structural issues, and at times even increases existing urban inequalities (Evans et al., 2019; Strüver et al., 2021). Given the corporate-driven nature of technology solutions, other aspects that drive inclusive urban development now include digital literacy and citizenship. Digital citizen participation in governance mechanisms is now a key component for achieving procedural equity and digital inclusion (Bouzguenda et al., 2019). Digital citizenship is not limited to skill acquisition but is a 'process by which individuals and groups committed to social justice critically analyse the social, political, and economic consequences of digital technologies' (Emejulu and McGregor, 2019), and can consist of a coordinated state plan for shaping the user's response to digital initiatives (Datta, 2018). Digital literacy contributes to inclusivity when it is combined with knowledge societies and digital entitlements, such as 'ICT infrastructure, policy implementation, human capital development, and the creation and endorsement of a culture of innovation', that promote inclusivity (Sharma et al., 2016).

The current discussion of the five dimensions of inclusivity, i.e., social, economic, spatial, environmental, and political inclusivity, is yet to incorporate newer challenges arising from adopting disruptive technologies. Recent literature highlights the increasing role of the digital divide, literacy, and citizenship in regard to inclusive urban development, with several calls for contextualising and calibrating technology solutions to ensure digital rights (Calzada, 2021) and for building cities that are smart yet inclusive in nature (Allam, 2018). Cities and their governments must therefore reconcile the motivations behind adopting such disruptive technologies and the challenges to inclusivity they may present. As a response, our systematic review analyses the interconnections between cities, technology, and inclusivity to extract the drivers behind technology adoption and the barriers they present to inclusive urban development.

3.4. Connecting cities, advanced technologies, and inclusive development

In this section we connect and explain the relationships between urban development models (represented by city labels), advanced technologies, and inclusive development. We do so by seeking to understand the motivations behind cities adopting advanced technologies. Despite the barriers they might present to inclusive development. Based on our analysis, the technologically driven urban development models discussed in academic discourse include smart, sustainable, eco, ubiquitous, intelligent, and smart sustainable cities, amongst others. Our analysis also reveals the main type of advanced technologies discussed – IoT and data platforms, AI and big data, autonomous systems and vehicles, and ICT-based devices and systems. These also overlap with previous categorisations of advanced or disruptive technologies

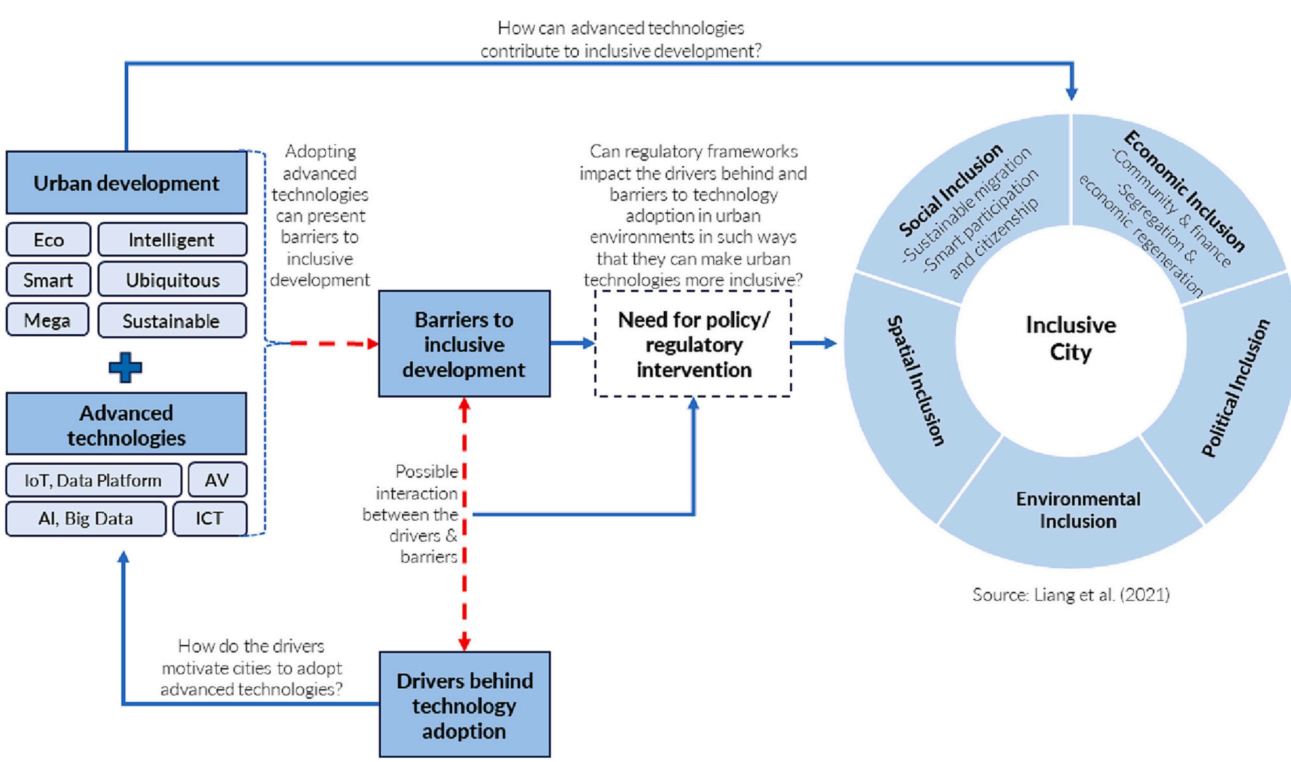

Fig. 2. Preliminary conceptual framework connecting cities, advanced technologies, and inclusivity.

developed by Radu (2020), Choi et al. (2022), and Ullah et al. (2018).

Several frameworks relating to technology-driven urban development are especially focused on smart cities. This is not surprising, as the academic discourse echoes smart city development within urban development. Smart city frameworks mainly highlight their multidimensional nature, consisting of resources, economic, societal, environmental, and governance dimensions, amongst others (Caragliu et al., 2011; Chourabi et al., 2012; Meijer and Bolívar, 2016; Yigitcanlar et al., 2018; Noori et al., 2021; Mora et al., 2023). They also focus on smart city transitions and development pathways (Mora et al., 2019; Noori et al., 2020; Mora et al., 2022). More recently, conceptual models and frameworks also connect urban development to the adoption of advanced technologies by developing a typology of smart urban innovation (Nilssen, 2019), acceptance of smart technologies (Sepasgozar et al., 2019), and a hybrid framework for understanding the innovation ecosystems in smart cities (Appio et al., 2019). Conceptual models on inclusive development and inclusive cities are also multidimensional, covering cities' 'multiple essences': spatial, social, economic, environmental, and political (Liang et al., 2021). These dimensions, although distinct, mutually complement each other and have synergistic interactions.

Based on our research questions, we propose a preliminary framework that connects the dimensions of inclusivity to a broader model based on technology-driven urban development (Fig. 2). We draw this linkage through the drivers and motivations behind cities adopting advanced technologies and their contribution to advancing the different dimensions of inclusive development. We posit that these different drivers push cities to engage with advanced technologies, given their potential contribution to inclusivity. Smart, sustainable, eco, and intelligent cities, amongst others, now consider the adoption of advanced technologies integral to their development model. These technologies include AI, big data analytics, autonomous systems, IoT platforms, and ICT-based devices. Embedding these technologies in the urban environment can provide improved access to and utilisation of urban services, participation opportunities, and increased transparency, amongst other benefits, contributing directly to the different dimensions of inclusive development. However, the adoption of advanced technologies can also have disruptive effects, hindering inclusive development through several mechanisms (discussed later). Some of the motivations behind adopting advanced technologies can also, conversely, contribute to barriers to inclusive development. Our framework places these motivations for technology adoption, and the barriers to inclusive development, as key nodes between technology-led urban development and inclusivity. We also suppose the need for a regulatory lens to address the above-mentioned barriers. In our analysis, we focus on identifying the motivations behind cities adopting advanced technologies, despite the challenges they may present to inclusive urban development. We also briefly present policy and regulatory recommendations for establishing connections between the nodes in our framework.

4. Drivers of technology adoption in cities

Systematically exploring the recent literature on technology-driven urban development reveals four key drivers behind adopting disruptive technologies: investment avenues and infrastructure development, developing human and social capital, encouraging citizen participation and e-governance measures, and increasing the efficiency of services (summarised in Table 3).

4.1. Investment avenues and infrastructure development

Cities and their governments adopt technological solutions to source additional investments and resources for developing physical and digital infrastructure, and use a mix of technological solutions to finance, scale and build essential infrastructure (Yigitcanlar, 2015; Marsal-Llacuna and Segal, 2016; Praharaj et al., 2018). Smart cities require a foundation of physical and digital infrastructure: broadband, wireless networks and optical fibre cables for connectivity, embedded systems and sensors for real-time data collection, digital applications for data analysis, processing, networking, and cloud computing (Schaffers et al., 2011), as well as telematics, augmented reality, context-aware computing, and geographic information systems (Yigitcanlar and Lee, 2014). It is therefore not surprising that IBM, Cisco, and Google are now involved in developing digital infrastructure in several smart city projects worldwide (Harrison et al., 2010; Yigitcanlar and Lee, 2014; Alizadeh, 2017; van den Buuse and Kolk, 2019; Carr and Hesse, 2020). Other examples include the involvement of larger consultancy companies in the design and management of command centres for smart cities in India (Praharaj, Forthcoming). Cities use such technologies to establish 'economies of scale' for infrastructure, increase network scalability and system interoperability, develop standards for digital applications, decrease the learning curve of smart solutions, and reduce their development costs (Schaffers et al., 2011; Yigitcanlar, 2015; Tan and Taeihagh, 2020). Developing digital infrastructure and technological solutions helps cities procure expertise and resources from private corporations and can improve their access to a wider population, but it also furthers the access and the overall standard of living of its residents – contributing in part to inclusive development. Examples include the 'Special Purpose Vehicles' in the smart cities programme in India, which are formed by inviting corporations to manage specific projects in conjunction with the municipal government. Here, given the requirements of infrastructure development and digitisation, local governments are expected to engage with private corporations to improve service delivery, ensure wider engagement with the general population, and increase the implementation of ICT and digital services across the project area (Praharaj et al., 2018). Cities participating in the IBM Smarter Cities Challenge also showed an interest in developing digitally enabled transport infrastructure using IBM's resources, to maximise accessibility and usage (Alizadeh, 2017).

Table 3
Drivers of technological adoption in cities.

Drivers of technological adoption in cities	
Investment avenues and infrastructure development	(Harrison et al., 2010, Schaffers et al., 2011, Yigitcanlar and Lee, 2014, Yigitcanlar, 2015, Marsal-Llacuna and Segal, 2016, Alizadeh, 2017, Praharaj et al., 2018, van den Buuse and Kolk, 2019, Carr and Hesse, 2020, Tan and Taeihagh, 2020)
Developing human and social capital	(Caragliu et al., 2011, Schaffers et al., 2011, Kitchin, 2014, Angelidou, 2015, Yeh, 2017, Lytras and Visvizi, 2018, Yigitcanlar et al., 2018, Ismagilova et al., 2019, van den Buuse and Kolk, 2019, Yigitcanlar et al., 2019b, Tan and Taeihagh, 2020, Zheng et al., 2020, Esposito et al., 2021, Goyal et al., 2021, Li et al., 2022)
Encouraging citizen participation and e-governance	(Gil-Garcia, 2012, Castelnovo et al., 2016, Gil-Garcia et al., 2016, Meijer and Bolívar, 2016, Alizadeh, 2017, Giest, 2017, Yeh, 2017, Chong et al., 2018, Pereira et al., 2018, Yigitcanlar et al., 2018, Bouzguenda et al., 2019, Emejulu and McGregor, 2019, Rotta et al., 2019, Tomor et al., 2019, van den Buuse and Kolk, 2019, Masucci et al., 2020, Nesti, 2020, Mossberger and Tolbert, 2021, Repette et al., 2021, Tang et al., 2021)
Increasing efficiency and optimising services	(Harrison et al., 2010, Kramers et al., 2014, Al Nuaimi et al., 2015, Angelidou, 2015, Marsal-Llacuna and Segal, 2016, Alizadeh, 2017, Bibri and Krogstie, 2017a, Giest, 2017, Marjani et al., 2017, van den Buuse and Kolk, 2019, Carr and Hesse, 2020)

4.2. Developing human and social capital

Cities also leverage the ubiquitous nature of technology solutions to build their human and social capital (Caragliu et al., 2011; Angelidou, 2017; Yeh, 2017; Zheng et al., 2020), developing both smart people and smart solutions (Yigitcanlar et al., 2018; Yigitcanlar et al., 2019b; Li et al., 2022). As key components in most smart city frameworks, high levels of human and social capital fuel 'sustainable economic growth and a high quality of life' (Caragliu et al., 2011) and provide the appropriate environment for successfully adopting technologically driven smart city strategies (Esposito et al., 2021). The operability and maximum utilisation of smart solutions depend on a design and operations team with sufficient technical skills to manage data collection, management, and analysis (Schaffers et al., 2011; Ismagilova et al., 2019; Tan and Taeihagh, 2020). The extended populations of smart cities also tend to be highly educated, reflecting a high base of social and knowledge capital (Lytras and Visvizi, 2018). Furthermore, the mindset of citizens is key to implementing smart solutions (Goyal et al., 2021): users need to be accepting of changes in service delivery (Yeh, 2017, Zheng et al., 2020). Therefore, smart city governments often focus on developing knowledge clusters where a skilled population can successfully navigate a technology-heavy environment (Kitchin, 2014; van den Buuse and Kolk, 2019; Tan and Taeihagh, 2020).

4.3. Encouraging citizen participation and e-governance

Digital solutions are a mechanism for increasing citizen participation and engagement with public agencies, and improving access to urban services (Pereira et al., 2018; Yigitcanlar et al., 2018; Bouzguenda et al., 2019; Emejulu and McGregor, 2019; Rotta et al., 2019; Tomor et al., 2019; Nesti, 2020; Mossberger and Tolbert, 2021). IT platforms also further political inclusion by allowing citizens to provide real-time contributions to urban solutions, which enables a higher level of commitment, legitimacy, and acceptance of the implemented policies and solutions (Chong et al., 2018; Masucci et al., 2020; Repette et al., 2021; Tang et al., 2021). It also reduces the number of intermediaries, induces increased monitoring of government actions, increases coordination within the government, and enables collaboration with external third-party agencies (Gil-Garcia, 2012; Castelnovo et al., 2016; Gil-Garcia et al., 2016; Meijer and Bolívar, 2016; Giest, 2017; Yeh, 2017; Bouzguenda et al., 2019; Nesti, 2020). Given the demand for e-governance solutions and ICT-led participatory mechanisms, local governments also engage private companies to facilitate the design and management of participatory platforms (Alizadeh, 2017; van den Buuse and Kolk, 2019).

4.4. Increasing efficiency and optimising services

Given the competition for limited resources, cities adopt ICT, AI, big data, and IoT systems to manage urban systems, remove redundancies, identify crucial sectors to target, coordinate and integrate, and provide a performance assessment of existing and new services (Harrison et al., 2010; Al Nuaimi et al., 2015; Angelidou, 2015; Marsal-Llacuna and Segal, 2016; Bibri and Krogstie, 2017a; Marjani et al., 2017). Cities also push for the use of advanced technologies in multi-system and multi-scalar collaboration systems to optimise the use and distribution of resources (Kramers et al., 2014; Marsal-Llacuna and Segal, 2016; Giest, 2017). For example, several smart city projects from IBM and Cisco consolidate and manage a large volume of data in order to monitor efficiency in smart homes, public squares, transport systems, and logistic channels (Harrison et al., 2010; Alizadeh, 2017; van den Buuse and Kolk, 2019). Apart from conserving existing resources, cities also apply AI-based safeguard mechanisms to limit the impact of crises, such as climate change and pandemics (Kramers et al., 2014; van den Buuse and Kolk, 2019). By adopting advanced technologies, cities can direct their use so as to achieve their environmental, social, and economic sustainability goals.

5. Barriers to inclusive development

Despite its advantages, ubiquitously adopting disruptive technologies presents challenges to inclusive development, so attention from planners and policymakers is required in this regard. A systematic analysis of the literature has helped us to identify four barriers to inclusion relating to disruptive technologies: the involvement of big tech companies; increased polarisation as a result of the digital divide; ethical concerns in designing digital solutions; and regulatory and policy capacity challenges (summarised in Table 4). We acknowledge that these barriers do not exist in isolation and may overlap and share certain common traits.

5.1. Increased big tech involvement in urban development

The increased involvement of big tech companies can compromise several aspects of social, economic, and even spatial inclusion, through their leverage, through information asymmetry, and through misaligned interests between these companies and local governments.

As discussed previously, cities are increasingly looking towards private corporations to broaden their resource pool, in terms of financial investment and human capital. Given the demand, tech companies such as Google, IBM, and Cisco are active in designing and developing smart and digital solutions (McNeill, 2015; van den Buuse and Kolk, 2019). IBM is a sought-after consultant for designing service management systems in cities, and has taken part as a long-term partner to formulate development strategies, sustainability goals, and performance indicators (Harrison et al., 2010; Alizadeh, 2017). Cisco develops ICT-based integrated platforms for bundling urban services, most visibly applied in Songdo, South Korea (Yigitcanlar and Lee, 2014; Mullins, 2017; van den Buuse and Kolk, 2019). More recently, Sidewalk Labs (a sister company of Google) was actively involved in the design of the IDEA district in Toronto (Carr and Hesse, 2020). However, such corporations prioritise their economic gain, which may not align with the public's interests of providing equitable access to services (Carr and Hesse, 2020; Mann et al., 2020). Here, investment in digital technologies is often selective, and its implementation discretionary (Odendaal, 2011). Big tech companies also hold a larger share of capacity and decision-making power

Table 4
Barriers to inclusive development.

Barriers to inclusive development	
Increased big tech involvement in urban development	(Harrison et al., 2010, Odendaal, 2011, Yigitcanlar and Lee, 2014, Hollands, 2015, McNeill, 2015, Alizadeh, 2017, Mullins, 2017, Cui et al., 2018, Lim and Taeihagh, 2019, van den Buuse and Kolk, 2019, Carr and Hesse, 2020, Mann et al., 2020, Austin and Lie, 2021)
Ethical challenges	(Kitchin, 2016, Loideain, 2017, Sholla et al., 2017, Cui et al., 2018, Bibri, 2019, González-González et al., 2019, Lim and Taeihagh, 2019, Chan, 2020, Lee et al., 2020b, Mercille, 2021, Rose et al., 2021, Tan et al., 2021)
Digital divide and polarisation	(Odendaal, 2011, Pick et al., 2015, Sharma et al., 2016, Tomor et al., 2019, Lee et al., 2020b, Masucci et al., 2020, Ranchod, 2020, Tan and Taeihagh, 2020, Shin et al., 2021, Taeihagh et al., 2021, Kolotouchkina et al., 2022)
Lack of regulatory and policy capacity	(Hollands, 2015, Meijer and Bolívar, 2016, Allam, 2018, Sankowska, 2018, Lim and Taeihagh, 2019, van den Buuse and Kolk, 2019, Carr and Hesse, 2020, Gohari et al., 2020, Mann et al., 2020, Ranchod, 2020, Tan and Taeihagh, 2020, Goyal et al., 2021, Taeihagh, 2021, Taeihagh et al., 2021)

compared to municipal governments, allowing them to use their leverage to manoeuvre around existing regulatory measures relating to digital rights, privacy, and social inclusion (Hollands, 2015; Cui et al., 2018; Lim and Taeihagh, 2019; Carr and Hesse, 2020; Austin and Lie, 2021). Apart from big tech companies, large consultancy companies are also key actors in developing smart solutions, such as command centres, particularly in developing countries (Praharaj, Forthcoming). Given the large scale of implementation and the complexity of command centres, urban governments with limited capacity often rely on these companies to operate them, leading to discretionary practices and thus a threat to social, economic, and even spatial inclusion.

5.2. Ethical challenges

Violations of ethical norms in applied technologies can present challenges to inclusivity, through systemic biases, disregard for data privacy, and a lack of neutrality in the applied technologies. While there is a requirement to apply social, cultural, and ethical norms in implementation (Sholla et al., 2017), it is still necessary to observe the dynamics between analytics, simulation and modelling, and the ethical issues involved in designing technological solutions (Kitchin, 2016; Bibri, 2019). The literature cites examples relating to incorporating ethical norms and principles into AVs and systems, and it shows that if this does not happen, it can lead to additional safety risks and discrimination in tech-driven urban environments (González-González et al., 2019; Lim and Taeihagh, 2019).

The lack of neutrality and the presence of systemic biases in technology solutions involves characteristics or mechanisms that unfairly or systemically discriminate against a certain group of people. The bias in the intersection of technology and urban development can stem from the start of data collection, in cases where it is difficult to opt out of direct or indirect data collection (Chan, 2020; Lee et al., 2020b). Such collection of data raises the possibility of systemic biases, with certain vulnerable populations unable to either contribute to and access facilities, or unable to prevent any violations of their right to privacy (Tan et al., 2021). Smart city projects, particularly those managed by tech companies, are more likely to be vulnerable to violations of data privacy laws (Loideain, 2017; Cui et al., 2018; Mercille, 2021; Rose et al., 2021). This data is also processed through algorithms, which, unless otherwise programmed and calibrated by designers, are unable to distinguish discriminatory functions and may vary based on the designer's moral standards (Kitchin, 2016; Bibri, 2019; Lim and Taeihagh, 2019; Chan, 2020). The large-scale replication of biased data and algorithms can propagate discriminatory practices, challenging the inclusive social, economic and spatial distribution of, and access to, resources.

The lack of articulation of ethical issues in development frameworks can also present challenges in implementing unbiased and inclusive policies. Lim and Taeihagh (2019) highlight challenges in detecting biases, including the excessive trust placed in AI by people, and the difficulty of proving the partial nature of AI, and its largely complex and opaque structure. Examples include the increased use of automation in providing long-term health care, particularly when solutions might vary on a case by case basis (Tan et al., 2021). Initial attempts at developing a framework that considers ethical considerations include the Ethics-Aware Object-Oriented Smart City Architecture framework, which introduces a separate layer for addressing ethical aspects of the city (Sholla et al., 2017). Other frameworks categorising social equity include holistic and ethical approaches in urban development design and implementation systems (Meerow et al., 2019). Both guiding frameworks and mapping possible sources of bias are useful for policymakers and designers in addressing emerging ethical challenges. Additionally, governments should consider using explicit guidelines on fairness and transparency, measuring and testing for biases in data, and designing measures in data and algorithms to mitigate bias (Lim and Taeihagh, 2019).

5.3. Digital divide and polarisation

Patchy access to digital technologies, structural imbalances between certain sections of the population (Taeihagh et al., 2021; Kolotouchkina et al., 2022), the presence of systemic differences in digital literacy and citizenship, and a digital divide amongst citizens and communities can exacerbate social polarisation (Odendaal, 2011; Sharma et al., 2016; Lee et al., 2020b; Masucci et al., 2020; Ranchod, 2020). Broadly, digital literacy is the ability of an individual or a group to use the internet and other digital devices to access and evaluate information (Sharma et al., 2016). The lack of digital literacy can lead to an increase in digital exclusion, as the former is increasingly required to access opportunities for economic and sustainable development (Masucci et al., 2020; Shin et al., 2021). A disproportional distribution of human and social capital can also exacerbate the digital divide (Pick et al., 2015) and the mismanagement of smart city initiatives, as well as presenting challenges to scaling them up. A detailed empirical investigation by Pick et al. (2015) into the leading causes of the digital divide in the United States highlights the importance of social capital, college education, urban research and development, and ethnic composition on the level of uptake in technological solutions and opportunities. Access to and use of such digital platforms is higher amongst affluent and technically capable participants who are better informed on urban policies (Masucci et al., 2020; Tan and Taeihagh, 2020). Additionally, the desired results from digital citizen engagement are limited when the participation process consists of non-deliberative actions, such as consultation, information dissemination, or political support-seeking (Tomor et al., 2019). Although cities increasingly attract and attempt to develop human and social capital and pursue citizen engagement as a driver of technological adoption, ignoring systematic variances can lead to uneven implementation and uptake of technological solutions, working against social, economic, and political inclusion.

Certain broad solutions are offered to improve ICT utilisation in cities but ICT policies are sometimes fragmented, with different government agency agendas challenging their uniform and unbiased implementation. Accordingly, ICT policies must be scrutinised to resolve discrepancies between their official aims and the implementation results, with an increased interaction between private investment and public directives (Odendaal, 2011). ICT training from a younger age, transparent design of smart solutions, support initiatives for certain ethnic groups, and funding for –-private partnerships can assist in ensuring the equitable adoption and productive usage of digital applications (Pick et al., 2015; Sharma et al., 2016). However, the solutions discussed to counter challenges to inclusive development arising from disproportional implementation and utilisation of digital resources do not consider associated barriers, such as limited monitoring and correctional resources applied by the government. Drivers of technological adoption, such as attracting investment opportunities for infrastructure development in smart city models, also reduce the attention that is paid to the equitable distribution of digital solutions. Further investigation is needed to understand how certain drivers of technological adoption may contribute to the digital divide and social polarisation.

5.4. Regulatory and policy capacity challenges

Cities require robust regulatory frameworks and safeguards relating to equitable design, distribution, and implementation of advanced technologies, particularly in developing countries. Through a systematic literature review, Tan and Taeihagh (2020) highlight that smart city projects in developing countries often lack a clear set of governance frameworks that specify policy aims, regulatory standards, and policy evaluation mechanisms. It is also difficult to form concrete regulatory and policy targets and objectives for governing advanced technologies, given their high degree of uncertainty and unpredictability (Taeihagh, 2021). A imbalance in power and expertise between private corporations and government agencies increases the existing information asymmetry and limits the effectiveness of existing regulatory measures (Hollands, 2015; Lim and Taeihagh, 2019; van den Buuse and Kolk, 2019; Mann et al., 2020; Taeihagh et al., 2021). Accommodating different market structures with varied political and private interests can adversely shape regulatory outcomes through advocacy coalitions (Goyal et al., 2021). Sidewalk Labs' proposal for the IDEA district, for example, illustrates the emergence of coalitions within the governance system. These coalitions steered the discussion on regulatory measures and eventually led to its closure.

Researchers have also raised concerns about smart cities ignoring the political connotations associated with the expected transformation of public administration. The governance models for smart cities are increasingly determined by large firms that frontstage urban problems that only their solutions can solve (Meijer and Bolívar, 2016; Gohari et al., 2020). Additionally, smart cities often require bureaucratic autonomy to enable greater discretion and innovation in decision-making (Ranchod, 2020), leading to the establishment of parallel governance mechanisms that exist separately from the existing political networks. The resulting discretionary use of regulatory measures can allow agencies to bypass established guidelines for designing and distributing digital services equitably (Carr and Hesse, 2020).

Adopting a laissez-faire approach in governance in such rapidly evolving circumstances can also lead to cities missing out on opportunities for economic development. Instead, government agencies need a unified authoritative system to steer multiple stakeholders and participants in ICT-led urban development. A lack of analytical capacity at the level of individual bureaucrats allows private technology companies greater leverage in formulating regulatory policies. Municipalities need to develop a certain level of digital competence so as to compete with the private sector, particularly in recruiting qualified experts (Sankowska, 2018). Countering challenges to social, economic, and political inclusion requires overcoming a lack of regulatory and policy capacity at various scales of government (Allam, 2018), while considering the underlying 'strategic, operational, analytical, political, and cultural factors' in the applicable context (Ranchod, 2020).

6. Discussion

In the above systematic review, we establish connections between (1) the different tech-driven city labels; (2) advanced technologies and their application in cities; and (3) the dimensions of inclusive urban development. Our comprehensive framework (Figs. 2 and 3) establishes these connections via the drivers that motivate cities to adopt advanced technologies and the barriers these technologies present to inclusive development.

Currently, smart cities dominate the discussion on tech-driven urban development, since it is widely accepted that technological solutions serve to improve efficiency in delivering urban services, optimise the use of existing resources, and upgrade the living standards of most – if not all – urbanites. In fact, even other types of cities, such as eco-cities, low-carbon cities, intelligent cities and knowledge cities, currently rely equally on tech-driven concepts and applications to achieve socio-economic and environmental goals, and hence are included in our

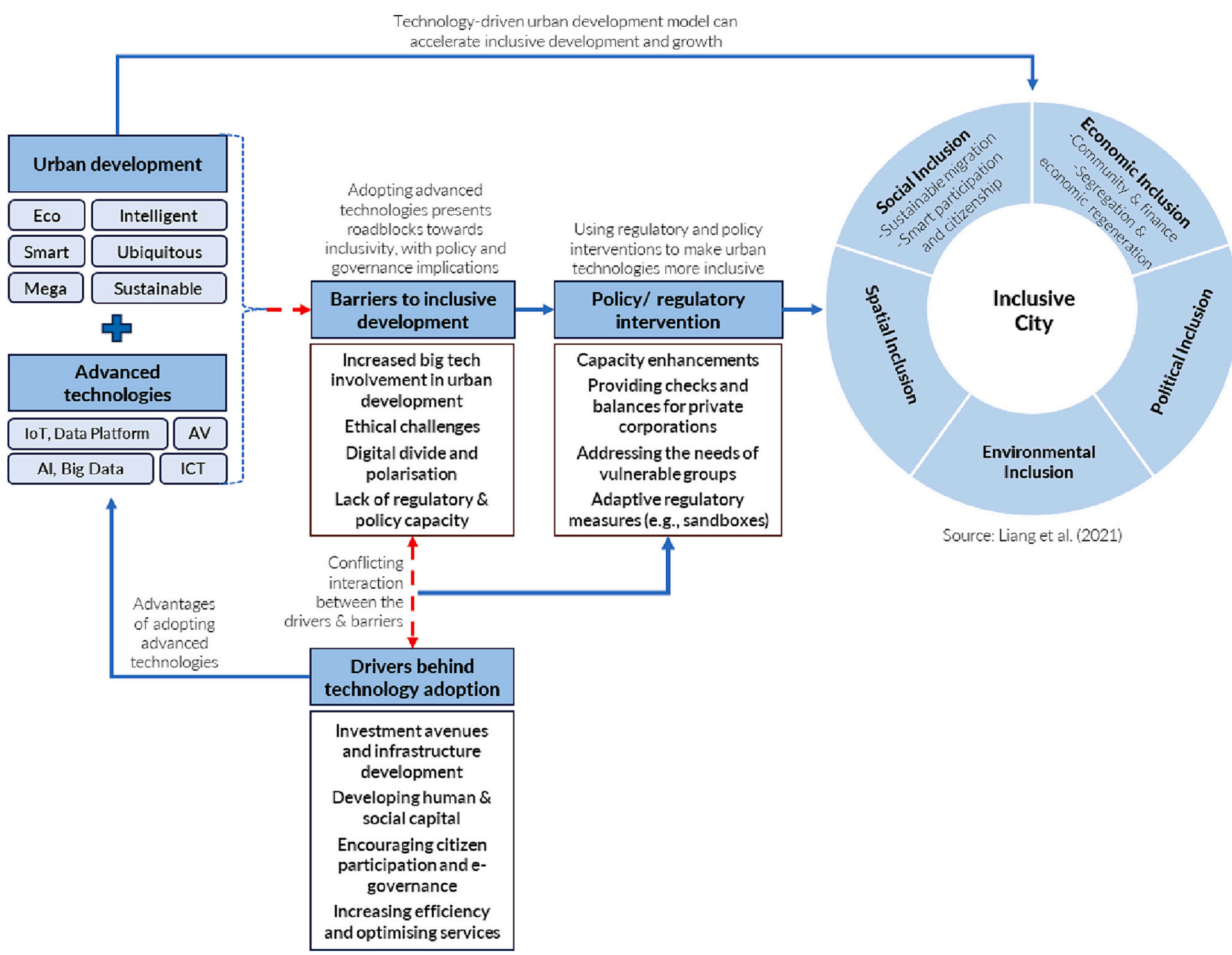

Fig. 3. Comprehensive framework connecting cities, advanced technologies, and inclusivity.

final framework (Fig. 3) Some of the dominant advanced technologies emerging in our analysis include AI and big data analytics, autonomous systems and vehicles, IoT platforms, and ICT-based devices, amongst others. However, despite their widespread use across sectors and scales, there is limited evidence to support the claim that advanced technologies contribute to sustainable – and therefore inclusive – urban development (Hollands, 2015; Bifulco et al., 2016; Bifulco et al., 2018; Evans et al., 2019). Moreover, several studies question the appealing but potentially deceptive corporate narrative behind many smart city policies, and rather consider smartness as a mechanism through which business interests are pursued at the expense of public needs in a competitive environment (Kramers et al., 2014; Hollands, 2015; Lim and Taeihagh, 2018). Our comprehensive framework reflects this issue, showing how the adoption of advanced technology can lead to barriers to inclusive development. Given the above concerns and the need for cities to redirect resources towards more inclusive and sustainable development, our systematic review identifies the primary motivations behind cities adopting potentially disruptive technologies (Fig. 3). The drivers behind adopting disruptive technologies are currently concentrated around cities' attempts to strengthen their position in a competitive environment. They use digital solutions to build a capable user base and competitive knowledge clusters that can attract new capital investment and a talented labour pool and create opportunities for further economic growth. Digital solutions also encourage citizen engagement, while increasing the legitimacy and acceptance of policies (Meijer and Bolívar, 2016; Bouzguenda et al., 2019). The technology-oriented approach to urban development therefore targets the improvement of the overall living standard and generally also aims at increasing the direct involvement of citizens in decision-making. However, it is often selective in the attention paid to various other aspects of social and economic inclusion.

Not all tech-driven city projects pursue digital inclusion and properly ensure general public online participation, or even have this as a main objective underlying public and private sector high-tech urban investment (Datta, 2018; Emejulu and McGregor, 2019). The involvement of technology companies (IBM, Cisco, Google) in designing and implementing technological solutions exacerbates existing power and knowledge asymmetries and strengthens structural dynamics, leading to greater inequality and exclusion. Additionally, given their higher leverage, capacity, and technical expertise compared to government agencies, global technology companies can mould regulatory measures to boost their profits, while compromising on many other public values. Private interests in urban development can also lead to discretionary implementation of smart solutions (Odendaal, 2011), particularly in Asia, where smart cities are prone to influence from corporate interests (Hollands, 2015). Such asymmetries, biases, and discretionary implementation of technology-oriented development impacts several dimensions of inclusion, including (but not limited to) social, economic, and spatial dimensions. In our comprehensive framework (Fig. 3), we acknowledge multiple mechanisms connecting the adoption of advanced technologies by cities to inclusive development. What clearly emerges is the need for regulatory and policy interventions that can help governments address and achieve their goals in regard to inclusivity. In the following sections, we briefly discuss some of these potential recommendations, focusing on smart city development, given its established dominance over the literature.

6.1. Policy, regulatory, and institutional aspects of smart city development to be examined

In our framework, we recognise the role of regulatory and policy interventions in targeting the different dimensions of inclusive development, incorporating mechanisms for capacity enhancements, adaptive regulatory measures – such as using experimental spaces and regulatory sandboxes, checking the power of and knowledge imbalances held by private companies, and targeting the specific needs of vulnerable groups. Such policy interventions (amongst others) allow cities to take advantage of advanced technologies, without delaying their adoption. In particular, governing the exclusionary risks of adopting advanced technologies requires a robust yet adaptive regulatory framework that can help to manage unintended consequences. Regulatory systems also require policy capacity across different levels of the government, i.e., 'a set of competencies and capabilities required to perform policy functions' (Wu et al., 2015). Cities can successfully utilise the benefits of advanced technologies when both design teams and citizens can navigate a tech-driven urban environment (Kitchin, 2014; Ismagilova et al., 2019). This is particularly relevant in developing countries, where smart city projects help source expertise and funding for infrastructure development (Yigitcanlar, 2015; Praharaj et al., 2018; Tan and Taeihagh, 2020). Adopting disruptive technologies also requires accepting new information in existing policies through an iterative process of adjustment (Li et al., 2021), as seen in the case of AV adoption in Singapore (Tan and Taeihagh, 2021). Policymakers can explore the role of anticipatory and adaptive governance models that accept the uncertainty of emerging technologies while promoting active engagement in their development (Cohen and Cavoli, 2019; Taeihagh, 2021; Tan and Taeihagh, 2021) for governing tech-driven cities. While technological changes tend to emerge and evolve quickly, and in often unexpected directions, legal rules and regulations are intended to promote stability and predictability in societal interaction patterns and are therefore adopted and amended cautiously. This mismatch in handling speed is likely to be harmful when technologies, applications, and standards themselves become the object of legislation, but can be managed more flexibly when legislation takes the shape of process-oriented or framework regulation, where procedures are followed which indicate which public, private and civil society actors have designated places at the negotiation table (and where and when) in decision-making regarding those technologies, technological applications and standards (De Jong and Stout, 2003; De Jong and Stout, 2007). Moreover, there is a growing literature on the dos and don'ts of sandbox regulation that allows policymakers and analysts to experiment with solutions and approaches to new technologies at a small scale and to examine to what extent these can and should be transposed locally or even nationally (Philipsen et al., 2021). Future research should explore how policymakers can incorporate newer dimensions of inclusive development in adaptive governance frameworks.

The relationship between technology companies and the regulatory design for advanced technologies also requires further investigation. There is an emerging discourse on the role of technology companies in guiding the trajectory of smart city policies (Söderström et al., 2014; Hollands, 2015; McNeill, 2015; Alizadeh, 2018). Google's IDEA district and IBM's Smarter City project illustrate how big tech companies can manoeuvre regulatory processes, particularly in regard to data privacy and management (McNeill, 2015; Carr and Hesse, 2020; Austin and Lie, 2021). Additionally, disruptive technologies present policy challenges in respect of information asymmetry, policy uncertainty, and structural imbalances, amongst others (Taeihagh et al., 2021). Adapting a 'civic political response' by local community leaders and activists can reduce the hegemony held by private corporations (Carr and Hesse, 2020). Other alternatives to top-down and corporate narratives behind smart solutions include using grassroots digital innovations (GDIs), where involving a wider range of private actors is seen as a counter to the monopoly of big tech companies (Gerli et al., Forthcoming). Given the increased involvement of technology companies in smart city development and the disruptive nature of advanced technologies, future studies need to scrutinise the existing regulatory processes for inclusive cities.

As shown in Fig. 3, the interaction between the drivers behind the adoption of technological concepts and their applications in the urban domain, and the barriers to making urban development sustainable and inclusive that exist, is important but often problematic. In this area of tension, different municipal governments in different parts of the world tend to make different policy and design choices, some of which horrify analysts, who cite cases of urban environments evolving into 'Frankenstein cities' where place branding, financial interests and authoritarianism prevail (Cugurullo, 2021), while others take broad public participation as the cornerstone of their policies (Calzada, 2018). A comparative study conducted by Raven et al. (2019) found that while Amsterdam (Netherlands), Hamburg (Germany), and Ningbo (China) all adopt the smart city as a city label, they understand this concept to mean very different things as regards the cognitive, normative and regulatory dimensions of policymaking. Likewise, Noori et al. (2020, 2021) have conducted a systematic analysis of the design choices on which the Barcelona, Amsterdam, Dubai and Abu Dhabi (Masdar) smart city projects are based. Using different input resources (human, financial, data, infrastructure) as project input, processing them in different leadership, management and governance styles and aiming to produce different types of outputs (application fields, such as health, mobility, energy, smart government and smart citizens) they find that, amongst the four, Amsterdam is primarily bottom-up in terms of its organisation, and is entrepreneurship- and innovation-driven; Barcelona has adopted participation, democracy and citizen empowerment as its core values; Dubai can be characterised as visionary-ambitious leadership-driven, with a state and service-oriented orientation of smart government; and Abu Dhabi is mainly guided by technological optimism, branding and a desire to secure external investment (De Jong et al., 2019; Noori et al., 2020). Although different models of what a smart city represents, as well as various developmental pathways, obviously lead to the adoption of digital technologies in the urban context, with differential impacts on the inclusion of various groups of societal groups in urban decision-making and the utilisation of local public services, not all practices can be applied in all institutional contexts. If Dutch analysts or policymakers lament the viscosity and lack of vision in their own smart urban development, embracing aspects of the Dubai model should be handled with great care, due to major cultural differences between the two cases. Similarly, anyone in Abu Dhabi seeking to promote digital democracy and strengthen citizen involvement must be eclectic in taking on board ideas from Barcelona, since institutional relations between government, businesses and civil society have historically evolved in particular ways in each case, which makes uncritical imitation a hazardous task. Inclusion is as relevant in Amsterdam and Dubai as it is in Toronto, but it is not fleshed out in the same way since different societal groups and facets of inclusion are prioritised in each cases (Anttiroiko and de Jong, 2020; Alsayel et al., 2022). Future research in smart and digital city development should pay heed to this conceptual, institutional and cultural variety, while maintaining a strong focus on the issues of sustainable and inclusive urban development as its normative cornerstone.

7. Conclusion

This systematic review has considered literature on (1) city labels in technology-driven urban development, (2) the application of advanced technologies in cities, and (3) inclusive urban development. We have extended this discussion by developing a framework connecting the above themes and linking them with drivers of adopting disruptive technologies and the challenges these technologies present to inclusive urban development. We have isolated the frictions between these drivers and barriers, which require further regulatory and policy interventions from governments when designing inclusive cities.

With the increasing popularity of smart city projects and the increased involvement of technology companies in urban development, governments need to design policies that engage with the drivers behind technology adoption, to address any conflicting barriers to inclusive urban development they may present, and to consider institutional specificities within and around smart city policies. In particular, we emphasise the need for a better understanding of the private sector's conceptualisation of inclusive urban development and its approach towards regulatory design for advanced technologies. We also propose that governments actively build policy capacity and consider adaptive regulatory frameworks that aim to secure the inclusion of vulnerable groups in society, to avoid the emergence or exacerbation of a systematic digital divide within the local population. Our future research agenda includes exploring the implications of technology adoption and the involvement of big tech companies for the different dimensions of inclusive cities: social, economic, spatial, environmental, and political.

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CRediT authorship contribution statement

Kritika Sha: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing, Visualization. **Araz Taeihagh:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Martin De Jong:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors report no conflict of interest in this manuscript to report.

Data availability

No data was used for the research described in the article.

Appendix A. Supplementary data

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