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Public Health Framework for Smart Cities within the Comprehensive Approach to Sustainability in Europe: Case Study of Diabetes

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Abstract: European cities should address the climate change challenges, improving quality of life and reducing costs. They need potential smart and digital approaches. Public health (PH) has recognized climate change as a major challenge. The development of urban policies should be guided by evidence-based PH practices. The environmental health determinants and the climate crisis now represent a clear PH threat. The core of the Smart City is sustainability, and its basic condition is active PH. The inclusion of public health into the pillars of the Smart City concept to contribute toward mitigating PH crises, such as the COVID-19 pandemic, is a framework for action. Design Science Research Methodology (DSRM) is used to elicit a Smart Public Health City (SPHEC) framework. A set of PH and smart city experts participated in the DSRM process, using diabetes as a case study. The European Green Deal served as a blueprint for this transformational change toward a healthier and more sustainable city. The SPHEC framework was defined by elucidating clearly the several dimensions of the PH functions within a digital city, via the identification of a set of digital PH services that are required to support the SPHEC framework. This allows for an assessment of the actual benefits that are obtained with the digital health services, and provides evidence for guiding decision-making. The role of digital PH services emerges from the analysis of the SPHEC framework, through the development of proper digital health services within the smart city, strengthening capacity and resilience in future climate emergencies, and motivating policy makers to take this challenge more seriously.

Keywords: urban health; smart city; environmental health; public health; European Green Deal; sustainability; digital public health

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1. Introduction

Around 75% of EU citizens live today in urban areas. Directly related to this, urban areas are also the places where the majority of energy demand and carbon emissions are generated [1,2]. Historically, the urban environment has focused on pollution, noise, disease, and the high density of the population. Nowadays, there is growing evidence of health and well-being impacts, both positive and negative, of the physical urban environment.

1.1. Smart Cities

"Smart Cities" is a relatively new concept that presents a set of perspectives that are aligned with a sustainability model that drives urban economy, mobility, environment, living, and people and governance [3].

The smart city term evolved from urban simulations and knowledge bases, and is still evolving to eco-cities [4]. Its definition ranges from mesh metropolitan information and communications technologies (ICT) environments, to various ICT attributes in a city, to urban living labs, or to the "smartness footprint" of a city, which is measured with indicators such as the education level of its inhabitants, the innovative spirit of its enterprises, CO_2 emissions, etc. Smart cities have attracted the international attention of international organizations (i.e., the European Union [5]) and big vendors from the ICT industry and electronics, as well as the transportation and services industries. More and more healthcare, and specifically, public health, are also becoming part of the concept.

All of these different meanings (and corresponding frameworks) address the scale and complexity of the smart city domain and describe alternative approaches, schools of thought, and researchers who deal with this relatively new field.

Smart Cities are supposed to benefit from their embedded ICT networks that are supported by a complementary digital data infrastructure, whereas the Internet of Things (IoT) will be one main component. IoT will enable the broad connection with the city citizens. Nowadays, citizens can already benefit from digital platforms such as Google maps, Uber, or Waze, which are digital platforms that literally work on being fed with valuable information by the network of (city) users.

1.2. A New Green Deal

The implementation of 70% of EU legislation for urban-led mitigation efforts, is the responsibility of local and regional authorities (e.g., cities). Despite considerable potential to promote measures to mitigate the impact of climate change authorities often lack the capacity, the resources, and the strategy to do so [6]. Europe's cities are recognized as crucial actors of the transition towards a climate neutral society to the 2050 goal. Cities must have the resources to support and to manage energy transition, digital transformation, climate mitigation and adaptation, re- and upskilling the workforce, pollution reduction, sustainable urban mobility and food systems, circular economy, and the strategic use of public spending to drive transformation while sustaining social cohesion [7].

In order to be effective, policies on climate, energy, zero pollution, circular economy, building, biodiversity, mobility, food, and digital transformation must increasingly be shaped by local experts and accompanied by new ways of working together with cities and citizens to achieve the necessary objectives, such as climate neutrality.

The European Green Deal (EGD) is a unique opportunity to align goals, efforts, and policies across levels of government to deliver results for the citizens of today and tomorrow. The opportunity of the EGD has brought a new and much needed motivation to the climate debate. Green Deal initiatives, from the Circular Economy Action Plan, to the EU Biodiversity Strategy and the Renovation Wave, make explicit references to both the needs and potentials of cities in the ecological transition [8]. The new Climate-Neutral and Smart Cities mission of the research and innovation program, Horizon Europe, supports 100 European cities in their systemic transformation towards climate neutrality by 2030, showcasing them as innovation hubs that can accelerate and lead on the Green Deal [9].

The importance of green space and biodiversity in European cities is highlighted in the EGD. The provision of green space in urban areas can influence health in multiple ways, including improved mental health, reduced cardiovascular morbidity and mortality, obesity, and the risk of type 2 diabetes mellitus (T2DM), as well as pregnancy outcomes [10]. Green spaces can also reduce urban heat islands and associated ill health, as well as reduce further energy requirements for cooling [11]. Nature-based solutions for adaptation and mitigation can protect biodiversity and can improve flood control and watershed protection, as well as act as carbon sinks, but potential unintended consequences such as increases in vector-borne disease transmission must be anticipated and addressed [12,13].

1.3. The Aim of the Study

This paper aims at exploring the role of public health and sustainability in the smart city concept, and proposes a Smart Public Health City framework. This framework will aim at supporting cities, developing their strategies and the researchers looking for research topics. The methodology and the results will be presented before discussing them, and identifying a set of the most relevant challenges.

2. A Smart and Healthy City

Here, we present a narrative review of the topics to be included in the Smart Public Health City framework design research methodology.

2.1. Public Health in the City

In the year 2000, it was estimated that nearly 47 percent of the population lived in urban areas, and this number is expected to rise to 60 percent by the year 2030.

As the process of urbanization progresses around the world, Health in Cities is a subject of growing public concern. The term "Health in Cities" was first coined by Sholom Glouberman and the Wellesley Central Health Corporation, in the report "A Toolbox for Improving Health in Cities." [14,15]. Public health is about the promotion and management of the general health conditions of a population within a region.

Modern urban planning is increasingly becoming connected to public health concerns. In the early 20th century, in order to help improve public health, urban planners segregated land use and regulations development (e.g., public gardens and pollution). This segregation, however, created sprawling cities, with negative effects on population health. This research seeks to understand how "ideas, interests, and institutions" related to public health and planning have interacted in the planning of our cities. Brisbane, Australia, is a case study exploring influences in public health and urban planning to better understand how their interaction has influenced local government institutions and the development of Brisbane's urban form [16]. Another example is the use of computer analysis to provide guidance while developing new PH interventions in the city [17].

2.2. Smart and Digital Opportunities

Smart cities can be thought of as cities that are capable of collecting and analyzing vast quantities of data, through diverse digital tools, including but not limited to low-cost sensors, data-actuated devices, and wireless communication networks. The collected data can then be analyzed to promote automated and intelligent processes (e.g., advanced data analytics), that can be used to improve the quality of the available services and to promote the emergence of new ones (such as the COVID-19 pandemic) [18].

Thus, it can foresee impacts in different sectors, such as economy, mobility, environment, education, living conditions, or governance [19].

Public health could also benefit from being part of this smart city system. These smart networks can be very interactive with the populations in promoting a set of healthy behavior, as well as alerting for riskier activities. Data can be provided on noise, air quality (e.g., as the result of some traffic jam), temperature, insects' locations, or infection diseases. Recently, as a response to COVID-19, contact tracing apps have been developed throughout the world. It is important to consider the public health opportunities within the smart city, such as the promotion of more physical activity, and improved mental health and food habits [20].

The WHO concept of "health in all policies" finds an excellent test setting in a city, whereas the smart city could leverage it to properly integrate these policies in terms of urban policy [21]. Smart cities data networks can enable a more real-time collection of health-related data that could be used in terms of policy making and actions. Preparedness will also be more easily deployed in the context of a smart city.

The World Health Organization's (WHO's) "Health Cities" is a valuable concept that can be leveraged within the public health area in the smart city [22]. The IoT is a valuable

platform for smart cities, by implementing IoT-driven services to improve the quality of life of its citizens, and through the collection and sharing of data that both captures the reality and promotes better behaviors. Cities are starting using IoT to study its potential. The possibility to engage many citizens in the process of collecting relevant public health data will enable the possibility of using both big data and machine learning tools to identify relevant patterns that can be used to support policy making. Interestingly, the WHO has defined the "Healthy Cities Network", which already has hundreds of members, creating the possibility of sharing experiences and promoting best practices for public health within the city.

Smart technologies have transformed urban life in many areas, and they could further reach out to the promotion of healthier cities [23]. However, the complexity of healthcare has limited its impact in smart city development. Therefore, a research and policy agenda should be developed to include it. This could include both the use of sensors in the public areas, as well as in citizens' homes. It is also of importance to use sensors for indoor health monitoring in smart cities [24]. The use of these sensors can be deployed to help improve the quality of life, especially when integrated with IoT reaching the citizens. However, there are some threats and safety issues that are related to IoT that still remain unaddressed.

The potential of big data and smart healthcare systems could help establish a new paradigm in smart cities [25]. There are already a set of big data and smart system technologies that could contribute to extending the smart city to public health activities. The inclusion of healthcare functions within the smart city concept will imply the creation of new expertise and a closer link between the municipality and the health institutions.

2.3. Smart City Examples

Singaporeans have the world's longest life expectancy, at 84.8 years [26]. This has been achieved in part thanks to a healthcare system that is oriented toward public health and disease prevention., The healthcare system is based on a universal health insurance system, where patients, not insurers, bear the costs of routine care. The state only funds a quarter of healthcare; the individual pays for the rest of it. Since the emphasis is put on funding the individual's own medical care, healthcare consumers will only spend when it is important, meaning that there is less strain on medical professionals. Since the individual has to pay for any medical care, there is a large focus on improving a healthy lifestyle and taking preventative measures to illness, such as managing stress, not smoking, and lowering alcohol intake. The system has been in use since the 1950s. Many health tech startups have played a role in improving Singapore's healthcare, and it is an example that could be applicable around the world [27].

Holmusk, founded in 2015 in Singapore, is a digital health platform that uses big data to tackle chronic diseases (e.g., diabetes, cardiovascular disease, and chronic kidney disease) and to influence positive health outcomes by monitoring data; using artificial intelligent technology (AI) will recommend lifestyle changes to improve health outcomes. They have also developed mental health management tools such as MindLink, with the goal of integrating a care model between mental and chronic health. DocDoc, another AI-enabled platform, is used for booking physicians' appointments online, based on the user's medical needs. The platform allows patients to find "the right healthcare at the right time" by combining expertise in clinical informatics, AI, and healthcare [28].

Barcelona is another example of pioneering smart cities, which uses new technologies aimed to develop a more energy-efficient, connected, data-rich, and high mobility city, to tackle environmental and social urban challenges such as climate change, energy transition, or sustainable mobility. They built their mission on understanding that "Internet and new technologies were a unique and incredible opportunity to transform the city and to rethink every single aspect of it: logistics, energy, education, healthcare, infrastructure, city management, public space, housing, security, mobility, etc. in a holistic approach" [29].

The Sentilo project, for example uses a network of about 19,000 active sensors that allows for the capture of real-time information on noise levels, temperature, air quality, or

the traffic flow of people and bicycles [30].This open data infrastructure also allows the Barcelona City Council to distribute municipal resources more efficiently and to offer new data-driven services that are suited to citizens' needs [31]. Barcelona has also implemented an innovative solution for better urban planning—the superblocks (mini neighborhoods with less traffic congestion, better air quality, and more leisure and green spaces). An electric city bike system was implemented, as well as a fast metropolitan tram system which has the highest rating by local users [32].

Strategic planning, as well as data-driven decisions (in the areas of energy and environment) are unique to each city, and so they are different environmental challenges for every city. Big data certainly are the answer, but each city should set its own questions based on what characterizes it, in terms of visions, policies, strategies, pathways, priorities, and actions [33].

3. Methodology

The Design Science Research Methodology (DSRM) was used to elicit a Smart Public Health City (SPHEC) framework. DSRM has six stages, that will be developed, as follows [34].

(1) Problem and motivation: Identify the (urban) public health functions that are key and that could be supported digitally within the smart city. This information will be obtained from both interacting with public health experts and the literature.
(2) Objectives for a solution: Developing Smart Public Health, with a sustainable focus within a smart city. Defining a framework of relevant health-related data to be collected from the smart city, and the tools required for its proper management, combining data from experts and literature guidelines (e.g., European Green Deal).
(3) Design and development: Together with the experts, an Interactive Smart Public Health City (SPHEC) information system framework was designed to enable the city to define specific policies and to guide the proper implementation of actions.
(4) Demonstration: The use case of diabetes mellitus care will be addressed in a comprehensive perspective within the public health smart city (SPHEC) concept. In this process of demonstration, both experts and the authors participated in the discussion.
(5) Evaluation: We will use a set of indicators (defined at stage 2) to evaluate the artefact. This information will also contribute to improving the framework.
(6) Communication: This task is addressed in this paper and the conclusions are presented in a set of public health and smart city conferences.

The Green New Deal (EGD) framework will be used. EGD underlines that all EU actions and policies will have to contribute to the EDG objectives. The challenges are complex and interlinked, and so the policy response must be bold and comprehensive, and seek to maximize benefits for health, quality of life, resilience, and competitiveness. For example, the EGD's "Farm to Fork" Strategy strives to stimulate sustainable food consumption and promote affordable and healthy food for all, as well as propose actions to help consumers choose healthy and sustainable diets and reduce food waste, which is very much linked with the case study of diabetes [35].

The EGD policy underlines that the response must be bold and comprehensive, and seek to maximize benefits for health, quality of life, resilience, and competitiveness. It will require intense coordination to exploit the available synergies across all policy areas [36].

The case study will focus on the specificities of diabetes management. Diabetes is now most prevalent in the populations older than 60 years old, representing a significant part of the city population and a threat for those without healthy habits. Type II diabetes can be prevented through healthy habits such as exercise and a balanced food intake, which we can see as a potential role for a smart and healthy city.

4. Results

Design Science Research Methodology (DSRM) was used to elicit a Smart Public Health City (SPHEC) framework. A set of stakeholders were engaged in the participatory

process: four experts in Digital Public Health and Smart Cities, Public Health Sustainability and Diabetes, and therapeutic patient education.

4.1. Problem and Motivation

The first stage was to define the need and motivation to integrate health management in the smart city concept. Therefore, key urban public health functions were identified and validated as being relevant by the participants. The generic functionalities are the following [19]:

- Information about water and sanitation usage and management;
- Information about air and noise pollution;
- Information about infection diseases (communicable diseases);
- Information about public places health and safety management;
- Information about promoting health well-being (such as proposed walking paths);
- A population-based information system.

Climate change-related functionalities:

- System and equipment hazard and vulnerability mapping;
- Extreme weather preparedness, and response plans and instructions;
- Extreme heat plans (including heat early warning and advisable locations);
- Non-heat early warning (e.g., flooding, vector-borne disease treats);
- Climate-health monitoring and outcome surveillance;
- Green space and biodiversity management.

4.2. Objectives for a Solution

At the second stage, it was to elicit Smart Public Health City (SPHEC) framework dimensions, including a set of indicators that were previously defined in the first stage. This should be an operational framework with a specific set of indicators and digital tools to leverage them, as proposed by the participants.

4.3. Design and Development

In this part, the design of a Smart Public Health City (SPHEC) framework was developed by taking into consideration both the problem and the objectives for a solution. The design of the SPHEC took a set of interactions with the participants before reaching a consensus (Table 1).

Table 1. City's Public Health Functions, Sustainability issues, and Digital and Smart City Approaches.

City´s Public Health Functions	Sustainability Issues	Digital and Smart City Approaches
Air quality control	Improve quality of air by reducing traffic and business emissions and reducing risk by informing the population about threats.	Disseminate digital sensors, and control the information from a control room for quick detection and response: The Smart Public Health City (SPHEC) framework
Water resources management	Control water consumption and reutilization. Alert for excess consumption and risks Green/Rewilded spaces	Develop app to interact and to provide useful information to the citizens
Noise control	Control automobile, motorcycles, and aviation traffic Urban (night life) noise	Develop app to interact and to provide useful information to the citizens
Stress control and mental health	Understand the city's main stress sources (violence, traffic tourism, poverty, etc.) [37]	Develop app to interact and to provide useful information to the citizens

Table 1. *Cont.*

City´s Public Health Functions	Sustainability Issues	Digital and Smart City Approaches
Control of non-healthy behaviors (food, smoking, drinking, mobility, . . .) that lead to chronic care conditions	Improve the mobility of people, promote autonomous vehicles, promote access to good quality and low carbon-footprint food, etc. [38,39]	Develop app with chatbot to dynamically interact with the citizens, promoting changes in behavior
Infection diseases control	Management of infection cases with low-print footage	Develop system to integrate infection information within the city health institutions
Food quality (Restaurants and schools)	Management of nutrition information and alerts	Develop app
Education and prevention	Dynamic Information System	Develop app to provide quality public health information

4.4. Demonstration: Smart Diabetes Management

As a case study, we chose to focus on the example of T2DM, a serious medical condition raised to pandemic proportions and a leading risk factor for other comorbidities, including many NCDs and infectious diseases such as COVID-19 [40]. T2DM is a chronic disease with determinants that are mostly dependent on human behaviors and habits [41]. T2DM management is a complex process since the disease has multiple factors. However, it could be better managed with an integrated approach within the smart city concept:

Air quality control: The Global Burden of Disease project has identified outdoor air pollution as one of the top five risk factors worldwide, with approximately 4 million deaths being attributable to air pollution in 2016, especially in low- and middle income countries [42]. Air pollution adversely affects many health outcomes, including respiratory and cardiovascular diseases, reproductive and central nervous system dysfunctions, and cancer [43]. Previous studies assessing the links between air pollution exposure and T2DM have been inconsistent. However, several recent systematic reviews and meta-analyses have found a significant association between air pollutants levels with T2DM incidence and prevalence, and that diabetic patients might be more vulnerable to air pollutant exposure [44]. The association between exposure to air pollution and T2DM may be related to an increase in thrombotic and inflammatory factors [45].

Globally, it is estimated that about 25% of urban ambient air pollution is the result of both car and airport traffic [46]. The smart city digital network could play an important role by expanding care at a distance (avoiding more traffic and reducing exposure to pollution), which has been proven to be effective in reducing travel-related fuel consumption and air pollution [47]. Several systematic reviews and meta-analysis have found these interventions (e.g., intervention via telephone call or SMS, Internet-based programs, video-conferencing, etc.) to be effective in improving glycemic control, adherence to treatment, diabetes knowledge, and patient self-efficacy, in both high- and low income settings [48,49]. Moreover, this digital network could provide real-time information and alerts to the population trying to limit the exposure to pollution. Besides traffic, it is estimated that air pollution contributed 15% to industrial activities and 20% to domestic fuel burning, which could be mitigated with the proper measures [50]. Several interventions aiming to address these different sources have been studied with varying degrees of effectiveness, including those aiming to address industrial sources (e.g., the closure of a factory), residential sources (e.g., a coal ban), and vehicular sources (e.g., low emission zones) [51].

Water resources management: Environmental toxicants have been implicated in the etiology of DM in epidemiologic and animal studies. Several compounds have been identified, including several heavy metals such as arsenic and lead, among others [52]. The mechanisms involve mitochondrial dysfunction and imbalances in reactive oxygen species, which can lead to impairments in insulin sensitivity, as well as insulin secretion from pancreatic β-cells [45].

The latest global estimates show that around 140 million individuals are affected by arsenic exposure that is above the WHO safety standard of 10 μg/L for drinking water, which has increased substantially over the decade [53]. Exposure to arsenic is mostly due to groundwater contaminations by naturally occurring processes such as rainwater leaching, weathering, and seismic and volcanic activities [47].

Lead can be released into the water from lead-containing components of water distribution systems, such as leaded pipes or faucets in buildings [47]. Neurodevelopmental, cardiovascular, renal, and reproductive health effects can be seen with blood lead levels as low as 10–20 μg/L [48]. In the USA, in 2000–2003, nearly 3% of drinking water distribution systems exceeded the lead level of 15 μg/L. Another study conducted in France found similar results in 2008–2009, where about 3% of dwellings had a lead in water concentration of above 10 μg/L, while around 1% had water lead >25 μg/L [47]. Although overall lead exposure levels have diminished in recent decades, there is an under-recognized but persistent occurrence of lead exposure in poor and underserved urban populations [47].

Many different sensors can be integrated within the smart city digital network, with unique advantages being designed using synthetic biology approaches, allowing for the early detection of traces of heavy metals in soil and water. This offers a sensitive, reproducible, and accurate procedure for environmental surveillance, permitting faster public health responses [54].

Noise control: There is increasing evidence in the literature that noise pollution might contribute to increasing the risk of T2DM [55,56]. It is hypothesized that noise acts as an environmental stressor, leading to the activation of the hypothalamic–pituitary–adrenal axis, which increases cortisol levels that inhibit the β-cell insulin secretion and peripheral insulin sensitivity [50]. Noise pollution can also cause sleep disturbances that can induce diabetes via appetite modulation and the general dysregulation of the metabolic and endocrine functions [50]. Primary sources of noise pollution include road and rail traffic, air transportation, and occupational and industrial activities [50].

It is safe to assume that by limiting the need to travel by using digital health sensors integrated in the smart city network, this will not only help reduce air pollution, as discussed above, but also noise pollution. Other mitigation solutions to traffic management include low emission zones, new types of pavements, new and sustainable vehicles, and innovative tire technologies [57].

Stress control and mental health: Stress can be defined as any factor that disrupts the homeostasis of an organism. The factors can be very diverse in nature. Simplistically, we can distinguish stresses as being of a physical nature (e.g., trauma) or being psycho-affective (e.g., anxiety, grief, or socio-professional conflicts) [58]. They have in common the fact that they induce physiological and behavioral adaptations of the person being subjected to stress, in order to regain the lost state of balance. This stress can lead to serious mental health problems.

The physiologic adaptation includes an interrelated response from the sympathetic adrenomedullary system (SAM) and the hypothalamic pituitary adrenal axis (HPA), as already described above. Initially, the SAM releases epinephrine and norepinephrine; if the stressor is sustained, the HPA comes into play [58].

Studies show that activation of the physiologic stress response from chronic exposure to stressors, low socioeconomic status (SES), severe mental health problems, or aggressive behavior also increases the risk of T2DM [59]. There is increasing evidence that stress management interventions may help to decrease stress and increase coping self-efficacy, stress management, and perceived social support, and lead to a better glycemic control among patients with diabetes.

Mobile phone health interventions comprising self-monitoring with or without therapy modules and multimedia content, have been found to be effective in treating both anxiety and stress [60,61]. However, these were not specifically evaluated for diabetic patients. The full implementation of the smart city network of digital sensors could address and reduce several relevant stressors.

Control of non-healthy behaviors: It has been shown that diet and physical activity are key in the prevention and treatment of T2DM [62]. With the global prevalence of T2DM tripling in the last two decades, some authors even call the rapid increase in T2DM rates as a 'Modern Preventable Pandemic' [63]. A small shift in lifestyle behaviors, such as increasing physical activity and the intake of dietary fiber, as well as reducing high energy dense foods and alcohol consumption, has the potential to reduce the diabetes burden and might be a suitable target for public health intervention [64].

Several digital health solutions already exist to help control non-healthy behaviors for the prevention and control of T2DM. These include educational tools (e.g., evidence-based reference materials, a chatbot service), the assessment of daily activity (activity tracker, heart rate, electrocardiogram, and sleep quality), and the evaluation of eating habits (the evaluation of meal time, frequency, total food intake, and calorie pursuing automation with the "food lens" function) [65].

Infection diseases control: There is a well-established link between diabetic status and an increased susceptibility to infection, which can be related to a direct immune-modulating function of insulin on various immune cells [66]. This is of particular interest in current times that are marked by the COVID-19 pandemic. Indeed, evidence shows that DM and poor glucose control represent crucial factors for a higher risk of a worse COVID-19 outcome. In one systematic review and meta-analysis, DM was found to be the best predictors for mortality in COVID-19-hospitalized patients, in an age- and sex-dependent manner [67].

In many countries, the COVID-19 pandemic saw an important increase in the use of telemedicine tools for the routine care of people with diabetes. The most frequently used tools included video call software (34.4%), phone calls (24.4%), digital data platforms (23.9%), and e-mails (10%) [68]. As previously discussed, these interventions are not only effective in improving disease-related outcomes, but they can help to prevent disease spread, and reduce air and noise pollution as well.

Food optimization and quality: The quality of the food is another important aspect in the pathogenesis of diabetes. Carbohydrate quality, for example, can be determined by evaluating the glycemic index (GI) and the glycemic load (GL). Low GI and GL diets are associated with a lower risk for diabetes compared with diets with higher GI and GL [69]. The quality of fat is also important. Diets that favor plant-based fats over animal fats are associated with a lower diabetes risk [69]. A diet that is rich in fiber, especially cereal fiber, may reduce diabetes risk compared to fiber from fruits [69].

Existing mobile apps can support in assessing food quality through rapid food testing, including food quality and freshness, nutritional and functional ingredients, adulterated ingredients, food additives, enzyme activities, and harmful substances [70]. These tools were tested in different age groups and different settings such as schools and workplaces [71], with varying degrees of effectiveness.

Education and prevention: Patient education is an effective solution for improving biomedical and psychosocial outcomes among people with metabolic disorders, including diabetes [72–74]. These educational interventions help people to understand the nature of their disease and empower them with resources to make informed decisions and to self-manage their symptoms and prevent further complications [75].

A growing body of evidence supports the use of digital health technology for improving patient education using a variety of formats (video, audio, interactive games, etc.), allowing them to adjust to certain topics and individual learning styles [76].

4.5. Evaluation

The case study helped to validate the model, by showing how the SPHEC framework covered the use of digital tools for PH problems within the smart city context. However, there were certain areas that still require some improvements. These were both the role of schools and of occupancy health in the smart city, as these require a broader approach with schools and companies much beyond the city governance expected role (usually at

the hands of the Ministry of Education). This means that cities have to go deeper into regulations to fully address the potential of smart cities (possibly also engaging the Ministry of Economics and the Ministry of Infrastructures and Transportations).

These misalignments with the initial model will be corrected, and a new framework version will be created.

4.6. Communication

Both this paper and the participation in Workshops at the European Public Health Conference 2020 (Rome, Italy) and 2021 (Dublin, Ireland) are components of this DSRM's stage [77,78].

5. Discussion

The SPHEC framework was defined by elucidating clearly the several dimensions of the public health functions within a digital city, and from that, eliciting a set of digital technologies that could be used to address and to mitigate the climate crisis, while tackling sustainability.

This analysis is complemented with a scoping review showing the evidence from other smart cities. The framework is accompanied by the identification of a set of Digital Public Health Services that are required to support the SPHEC framework. In this regard, it is important to assess the actual benefits that are obtained with the health digital services, giving evidence on the righteousness of the decision-making.

Finally, using T2DM management as a case study helped validate the framework. Several effective Digital Public Health solutions were identified that could help to address the global diabetes pandemic. These strategies, if implemented properly, have the potential to improve not only diabetes care, but also tackle other noncommunicable diseases (NCDs) that share common risk factors (e.g., obesity, poor diet, inactivity, and smoking) and improve general population health.

Framework Comments

Climate change is recognized as the biggest challenge for health and sustainability today. The Green deal is already an established roadmap to not only build a new economic model, but also to set the blueprint for this transformational change towards a healthier and more sustainable future, especially in cities where the majority of EU citizens live. Cities are the central place of life for the majority of EU citizens, but also globally. The necessity for information about water, sanitation usage and management, air and noise pollution, infectious diseases, public places, health and safety management, places which promote health well-being, as well as population-based information systems, are inevitable [79].

The European Green Deal roadmap has a goal to draw up "deeply transformative policies" as a mainstream sustainability and climate action in all EU policies and programs, aiming to foster long-term systemic change. This is not only requires significant macro-level economic, infrastructural, and technological innovation, but also micro-adaptations in lifestyles, behaviors, and the consumption patterns of citizens.

Smart cities planning attempts to decrease resource usage by leveraging digital technologies and intelligent solutions for housing, energy, and water and waste management, as well as mobility. They are also some sorts of laboratories for innovation (using a cross-sectoral approach to smart cities) and transformative change, towards effectively driving behavioral shifts and an engagement in the sustainable habits of their citizens (e.g., start-up eco-systems). With all EGD pillars and aims included, there is a great opportunity for pushing for public health improvement that is supported by appropriated digital technologies [13].

It is important to mention that the new "European Bauhaus" brings the Green Deal into our living spaces, and engages citizens in the process of co-creating the vision for the sustainable, healthier, aesthetic, and smart cities of tomorrow [80].

The Mission Area for Climate-Neutral and Smart Cities, which is fully anchored in the European Green Deal, approaches urban climate action as an integral part of the broader sustainability policy for all citizens. The Mission aims to enhance cities' role as accelerators of Europe's green transition by acting as laboratories for experimentation and innovation. The Commission "support, promote and showcase 100 European cities in their systemic transformation towards climate neutrality by 2030 and make these cities into experimentation and innovation hubs for all cities, thus leading on the European Green Deal". Diabetes mellitus as a big public challenge also requires innovation, which could be inspired and developed under the umbrella of the Smart Public Health City framework [81].

Kalra et al. underline that the concept of Sugar Smart and Heart Smart cities is a rational one. This method, on the off chance that it is actualized appropriately, has the potential to make strides not as it were in NCD care and health in urban settings, but to also contribute to urban growth. A detailed consideration to these propositions, counting them as an fundamentally portion of Smart City advancement, is the need of the hour [82].

The limitation of our research is that we included just one example—smart diabetes management within the smart city context. Future studies should extend this to other examples, to clinical trials, and eventually, to include more than just one disease.

6. Conclusions

Clearly, the role of Digital Public Health Services emerges from the analysis of the SPHEC framework. This framework should be promoted to tackle the development of proper digital health services (and new business models) that are supported by the smart city, including the capacity and the resilience to address any climate emergency situation that might emerge, and to motivate policy-makers to take this challenge more seriously. This work is contributing to SDG3, improving health, to SDG4, allowing for the provision of distance health education at relatively low cost, and to SDG 13, reducing the CO_2 footprint (sustainability).

Digital Public Health Services are useful at the individual level (i.e., the citizen level) and at the level of the community. Moreover, DPHS also sees the city as a patient, and monitors its metabolism using smart technologies, towards saving and improving the infrastructure (and health) of the city, making it greener and more sustainable.

The example of digital public health services for T2DM management, as presented in this article, should provide a good start for teams that are willing to develop these interventions for smarter public health decision-making in T2DM control and prevention. However further research is required to evaluate their effectiveness. It is hoped that this article will stimulate further research and discussion among public health communities in this sense.

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