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Health and Mobility in the Post-pandemic Scenario. An Analysis of the Adaptation of Sustainable Urban Mobility Plans in Key Contexts of Italy

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Abstract. The combination of concerns about the Covid-19 pandemic and structural problems relating to social injustice, climate change, and public health requires a radical reorganisation of transport structures, urban services, and the built fabric of metropolitan regions. This need is central to the pandemic era's public debate: more significantly, it is reflected in the stimuli to metropolitan and urban policies aimed at adapting regional and mobility plans in order to realise a model of a smart, inclusive, sustainable, competitive and resilient city. The paper proposes a comparative content analysis to investigate the SUMPs adopted by the Italian metropolitan cities of Milan and Bologna, as well as their modification via the adoption of emergency plans and adaptation strategies for the post-pandemic scenario. The study's purpose is to deduce a set of transferable guidelines. Based on earlier research, this study selects the Metropolitan City of Cagliari as a case study for implementing the set of guidelines derived from the comparative content analysis. The study significantly contributes to urban studies by investigating the transformation of concepts and criteria that underpin transport and mobility policies in the Italian context.

Keywords: Sustainable Urban Mobility Plans · Health · Pandemic · Urban policies

1 Introduction

The increasing social, economic and environmental impacts of mobility dependency on private motorised transport have determined the need for a radical transformation

This paper is the result of the joint work of the authors. 'Abstract' 'Methodology', and 'Selection of the Case Study' were written jointly by the authors. Alfonso Annunziata wrote the 'Literature review'. Giulia Desogus wrote the 'Results'. Francesca Mighela wrote the 'Introduction' and Chiara Garau wrote the 'Discussion and Conclusions'. Chiara Garau and Francesca Mighela coordinated and supervised the paper.

of transport policies in recent years. According to the European Strategy and Policy Analysis System [1], the transport and mobility sectors influence cities' climate change, energy consumption, and pollution levels. The European Union (EU) has promoted legislation to foster the integration of sustainable mobility projects and new modes of transportation in order to mitigate mobility and its associated consequences in large cities. Since 2013, the need for more sustainable and integrated planning protocols has been recognised [2, 3].

The EU has identified the Sustainable Urban Mobility Plan (SUMP) as a paradigm shift in urban transport planning. The SUMP is defined as a strategic plan to boost people's quality of life by assuring universal access to services and urban amenities and by strengthening the social, economic, and environmental sustainability of urban mobility systems [4, 5].

Moreover, the need for social distancing, the consequent reduction of the number of public transit users, and the modification of social and individual practices that underpin pandemic and post-pandemic scenarios requires a radical re-organisation and re-structuration of the city and, in particular, of the mobility system [6]. Consequently, municipalities and metropolitan cities are faced with the challenge of revising and adapting SUMPs, that have been implemented or are already being prepared to meet the requirements arising from the pandemic emergency's demands.

The present study is concerned with the Italian situation. It includes a comparative content analysis of the SUMPs and of the adaptation strategies formulated by the Metropolitan Cities of Milan (MCMI) and Bologna (MCBO). The aim is twofold: 1) to examine how the conceptual premises and policies included in the SUMPs have evolved or can change in response to the post-pandemic scenario needs and 2) to define a set of guidelines transferable to other metropolitan areas, and in particular to the Metropolitan City of Cagliari (MCCA). The relevance of this study is based on two aspects: firstly, it frames the discourse on smart and sustainable mobility within the general discourse on the re-organisation of urbanised areas, underlining the need for integrating transport and urban strategic plans at the metropolitan scale. Secondly, it highlights the centrality of interdependencies among transport infrastructures, land uses and metropolitan scale amenities, and built-up areas as a central aspect of strategies for adapting metropolitan areas to the post-pandemic scenario.

The article is divided into five sections. Following the introduction, Sect. 2 discusses the structure and aims of the SUMP and strategies for cities' adaptation to the post-pandemic scenario. Section 3 illustrates and describes the technique and case study. Section 4 summarises the relevant findings of the comparative content analysis of the SUMPs and the adaptation strategies adopted by the MCMI and the MCBO. Finally, Sect. 5 discusses the significance of the findings for developing a set of transferrable guidelines.

2 Literature Review

The European Strategy and Policy Analysis System [1] underlines the transport sector's impact on climate alteration, soil and energy consumption and pollution levels in cities. These problems have led to a deterioration in citizens' quality of life. For this reason,

mobility and transport [7] have become central concepts in the scientific literature on urban development and social and environmental sustainability and in public debates on the main European and international initiatives concerning smart cities and sustainable mobility. Coni et al. [8] provide an example of a smart, sustainable, and green mobility transition. The authors outline the strategic plan adopted by the Metropolitan City of Cagliari. This plan includes implementing Intelligent Transportation Systems (ITSs) technologies, improving routes and fleet buses, limiting vehicular traffic in the historic centre, extending pedestrian areas, developing a network of cycle paths, promoting car-sharing, car-pooling, bike-sharing, electric mobility, and completing and integrating the tramway network.

Citizens' lifestyles have altered as a result of these actions: they began walking, running, cycling, and taking public transportation, discovering a new way to explore their city. As a result, public transportation services play a crucial part in the sustainability of cities, and regardless of how appealing they are, citizens might consider them as a real and practical instrument for getting around a city and fostering sustainable mobility [9]. For a public transport system to be attractive, it must meet users' needs. Several authors have focused on the aspects that are essential for them, analysing the quality of these services through a survey campaign conducted among passengers [10–15]. Therefore, a good public transport system is a key aspect of a smart city for ensuring mobility opportunities for all citizens, containing the environmental impacts generated by traffic, and improving road safety.

Besides, in terms of healthy cities, air pollution, noise, congestion, and accidents, sustainable mobility has become the primary goal of EU initiatives and current research on the subject of smart city 3.0 [16–20]. Indeed, the EU has increasingly encouraged policies focused on sustainable mobility projects and integrating new forms of mobility to significantly reduce pollution in large cities. Within this perspective, the EU introduces a new paradigm for urban transportation planning by adopting the Sustainable Urban Mobility Plan (SUMP) [21, 22]. The "SUMP" is defined as a strategic plan that aims to deliver a higher quality of life, while also meeting the mobility needs of people and businesses in cities and their environs. SUMPs are based on current planning methodologies and consider the notions of integration, participation, and evaluation [23]. Thus, the SUMPs are based on principles designed to guarantee that the EU's goals for a competitive and resource-efficient European transportation system are achieved [8].

According to Troisi et al. [23], SUMPs are no longer exclusively concerned with the concept of mobility, but rather with sustainability, embracing a human-centred focus [24]. Sampaio et al. state that "SUMPs were established and implemented to reduce externalities associated with transportation by outlining various methods to improve the efficiency and sustainability of urban mobility" [25, p. 1].

Italian Institutions acknowledged in 2017 the importance of SUMPs as the fundamental tool for establishing a balanced, sustainable, and effective system of mobility and access. Indeed, the Italian Ministry of Infrastructure and Transport (IMIT) adopted the rules for SUMPs in 2017, dubbed "Piano Urbano della Mobilità Sostenibile – PUMS" in Italian. The national regulations are based on the publication "Guidelines. Developing and Putting in Place a Long-Term Urban Mobility Plan" [26, p. 9] and define the structure of the drafting and adoption process of the SUMPs, the reference strategies,

the general and specific objectives, and the indicators to be used in determining if the SUMPs' goals are met.

More precisely, the European and national legislation - particularly the instructions provided by the European Commission's Directorate-General for Mobility and Transport and the Italian Ministry of Infrastructure and Transport's decree of 4 August 2017 – identify the eight stages of the drafting of the SUMP: i) Definition of the interdisciplinary/inter-institutional group of work; ii) Preparation of the baseline scenario that describes the current situation; iii) Start of the participatory process; iv) Definition of objectives; v) Participatory construction of the Plan scenario; vi) Strategic Environmental Assessment (SEA); vii) Adoption of the Plan and subsequent approval; viii) Monitoring. In particular, the participated construction of the plan scenario is articulated in three stages: i) the development of a reference scenario that describes the transformation of the metropolitan area as a result of the evolution of socio-economic trends and the completion of planned interventions in urban form and infrastructures; ii) the development of alternative scenarios, comprising alternative sets of measures; iii) the evaluation and comparison of sets of alternative measures and the development of the Plan Scenario. Thus, the formulation of the project scenario derives from an iterative process of perfecting the measures comprised in the alternative scenarios: these alternative measures are evaluated in terms of economic, financial, and managerial sustainability, and of expected benefits resulting from the reduction of congestion, consumption, and emissions, and from the improvement of safety, and of the quality of life of citizens. The alternative measures, considered to meet the requirements and quantitative targets defined in the preliminary stages, are then combined and integrated into the Plan scenario. Consequently, the Plan Scenario formalises the strategies and the related actions that structure the Sustainable Urban Mobility Plan. Lastly, the Plan's specific objectives must refer to four general purposes, including i) the development of access and the functionality of the transportation system, ii) environmental sustainability; iii) socioeconomic sustainability, iv) road safety; v) Improved integration of mobility system development and territorial organisation and development (residential areas and urban planning for economic, cultural, and tourism poles);

The mobility and urban structure organisations are made particularly urgent by reducing available resources and the permanent, radical modification of social practices determined by the Pandemic. Consequently, the post-pandemic scenario poses the need for public actions that combine the goal of the economic restart, the purpose of contrasting climate alteration, and the intent of re-structuring spaces, infrastructures, and urban functions/ services to meet sanitary precautions and to accommodate the modified lifestyles [27].

The Italian National Institute for Urban Studies (INU) states that the need to ensure substantial consistency among relevant and diverse objectives postulates the relevance of future visions and strategic plans as instruments for facilitating the transition to a new development model [28]. Hence, strategic plans and future visions emerge as a central aspect of implementing the European strategy of the Green Deal. This strategy intends to mitigate the adverse outcomes of climate alteration and the construction of fairer and more sustainable urban environments via the decarbonisation of the productive system,

the promotion of circular economy and sustainable tourism, and urban regeneration [29–31].

Within this perspective strategic plans must include specific lines of actions related to the re-organization of mobility structures, the built-up areas, urban equipment and facilities and the public space, including: i) the promotion of sustainable mobility by expanding the system of pedestrian and cycle routes, the regeneration and valorisation of open spaces contiguous to pedestrian and cycling surfaces; ii) the increase in the service offer of metropolitan rail systems and local transport system; A peculiar problem regards the increase of motorized private transport travels to replace public transport trips, as a consequence of concerns related to inter-personal distancing and the reduction of contacts; iii) the modification of public transportation nodes, including the adaptation of platforms, to accommodate longer trains, configured to increase the capacity of public transport and ensure physical distancing; iv) the modernization of secondary roads, particularly in the marginal suburban areas; v) the regeneration of public spaces and of road spaces, aimed at improving and creating public spaces for social and recreational activities, including green areas, parks, gardens, natural and semi-natural areas, and urban vegetable gardens [32, 33]. The subsequent section describes the methodology with the case study. It investigates the actions proposed by the SUMPs and the Emergency Plans of the Metropolitan Cities of Milan and Bologna to meet the objectives of climate resilience, salubrity, and social and economic sustainability.

3 Methodology

The analysis focuses on the Sustainable Urban Mobility Plans of the Metropolitan cities of Bologna and Milan. It investigates the mobility systems' adaptation strategies to the pandemic and post-pandemic scenarios.

The analysis is articulated in four stages: i) a content analysis of the documents describing the SUMP; ii) a content analysis of the documents presenting the adaptation strategies adopted for the post-pandemic scenarios; iii) comparison and identification of the most significant modifications in the conceptualisation of the urban environment, public spaces and mobility structures; iv) identification of most significant actions proposed to combine the objectives of the SUMP and the need for improving the sustainability, inclusion, resilience, and salubrity of the built environment, determined by the COVID-19 pandemic [37].

The comparative content analysis investigates and compares the contents of the selected SUMPs and of the adaptation strategies related to specific dimensions of metropolitan mobility.

These dimensions include road infrastructure, pedestrian and cycling infrastructure, public transportation, circulation, parking, urban form, and mobility culture.

Moreover, the specific dimensions of the actions proposed by the SUMPs and by the Adaptation strategies are articulated in several sub-categories related to distinct aspects of the components of the urban environment. More precisely, the category road infrastructures include the sub-categories Configuration, Maintenance, Composition, Intersections, and Coexistence. These sub-categories refer to the configuration of the system of roads and open spaces, the functional conditions of the road infrastructure equipment,

the composition of the road space, the design of intersections, and the co-existence or competition among road functions. Public transport is described in terms of configuration and arrangement of infrastructure, service offer, configuration, design, and functional diversity of stations and nodes. The configuration of land plots and buildings, land use pattern, the location of large-scale facilities, such as industrial regions and functional poles, and the configuration of metropolitan ecological infrastructure are the considered aspects of urban form. Lastly, parking infrastructure is described as availability, determined by its size and density, distribution in relation to arterial infrastructure, and location concerning road space. The findings from the comparative content analysis are then utilised to define a set of guidelines for drafting the SUMP for the Metropolitan City of Cagliari. A description of the case study is presented in the subsequent section.

3.1 Selection of the Case Study

The study focuses on SUMPs adopted by the metropolitan cities of Milan and Bologna. These SUMPs are selected based on four criteria: i) participation in the Italian SUMPs Observatory initiative; ii) state of advancement of the SUMP; the analysis focused on approved SUMPs; iii) scope of the SUMP. The study identifies as the unit of analysis the metropolitan area to understand the entire field of socio-economic interdependencies that engenders the demand for mobility involving urbanised areas; iv) Publication of guidelines for the adaptation of mobility and urban policies to the post-pandemic scenario. The preliminary analysis of the SUMPs underlines the criticalities of the present scenarios and the general objectives identified by the Local government of the Metropolitan Cities of Milan and Bologna. The main criticalities concern the configuration of the road infrastructure, the configuration and organisation of the public transport system, the anisotropic distribution of services and amenities, and the quality of the public space. Important concerns are related to the misalignment of the configuration of the public transport system in relation to the transformation of the urbanised area: The radial structure of the main routes of the Public transport system is no more adequate to serve the transport demand engendered by tendencies of Dispersed urbanisation and by the emergence of new centralities in suburban areas, constituted by residential areas, service poles, industrial and logistic facilities, transportation infrastructures, places of consumption, and recreation.

Another issue is the lack of coordination between different modes of public transportation, the misalignment of the distribution of transportation demand with the structure of the public transportation service offer, and the existence of sparsely populated areas that are not served by public transportation. In terms of active mobility, the SUMPs underline the cycling route discontinuity and the concentration of high-quality pedestrian areas, such as pedestrian areas, Privileged pedestrian Transit areas, and limited transit zones, in the central districts of compact urbanised areas. These conditions result in the unbalanced modal split and the dominance of private motorised transport. The latter, in turn, emerges as a primary determinant of emissions of pollutants, including Nox, CO2, PM10, PM 2.5, COV, energy consumption, and road accidents.

On the other hand, the Metropolitan City of Cagliari is selected based on four criteria: firstly, the initiatives of local authorities in terms of policies aiming to foster sustainable modes of transport. In particular, the procedure for adopting a metropolitan and for an

urban SUMP started, respectively, in 2019 and 2018. Moreover, the program document for the Strategic Plan of the Metropolitan City was approved in 2021;

Secondly, the unbalanced distribution of services and amenities, among central, vibrant, compact districts and suburban areas and the emergence of specialised poles of function along main road infrastructures inadequately served by public transport. A relevant aspect concerns the unbalanced modal split: the reliance of mobility in the metropolitan area on private car-based travel determines an intense pressure on arterial distributors and on the system of urban primary and secondary distributors. In particular, recent surveys conducted in 2017 measured 175,639 vehicles per day entering the urban area of Cagliari in May and 162,272 vehicles per day in August.

The last considerations refer to the inadequate usability of pedestrian spaces outside the pedestrian areas located in the compact central districts and the discontinuity of cycle itineraries. The findings from the comparative content analysis are presented and discussed in the subsequent section.

4 Results

The SUMPs of the Metropolitan Cities of Milan and Bologna identify the balancing of the modal split, the improvement of conditions of access to transportation, services, and employment, the usability of public open spaces and transportation infrastructures, the reduction of road accident casualties to zero by 2050, the reduction of CO_2, NO_2, and PM_{10} emissions, and the reduction of soil consumption as fundamental targets.

These objectives, related to the general aim of improving the sustainability, inclusivity, safety, resilience and salubrity of the metropolitan areas, are pursued via the Avoid, Shift, Improve (ASI) paradigm. The ASI paradigm refers to the adoption of strategies aimed at reducing long-distance trip demand (Avoid), promoting the transition to more sustainable modes of transportation (Shift), and minimising the outcomes of private transportation by encouraging a transition to low-emission vehicles (Improve).

The avoid dimension, for instance, is actualised via measures of land-use and built-environment re-configuration and of mobility management in private companies and public institutions, aimed at decreasing the need for long-distance travel.

The Metropolitan City of Milan's SUMPs proposes that the development of planned communities be subordinated to the verification of the resultant prospective mobility demand. Finally, the SUMP of Bologna Metropolitan City presents a set of criteria for urban regeneration and densification interventions, as well as interventions in urban development. These criteria include i) dimensioning these interventions based on the transport system's capacity; ii) increasing building density and diversity of Land Uses in areas adjacent to MRS nodes and intermodal centres; iii) limiting dispersed urbanisation by locating urban development interventions along the edge of densely urbanised areas with a significant density and diversity of services, and iv) relocating the building capacity of rural areas.

The modal transition, vice versa, is realised via the re-organization of the public transport system: a relevant aspect is the introduction of transversal public transport routes to serve the transportation demand originating in suburban areas and attracted by emerging centralities located in dispersed urbanisation areas.

The integration of distinct public transport modes into a multi-level, pluri-modal metropolitan transport system and the re-configuration of transport nodes as intermodal hubs are central actions identified by the studied SUMPs to improve public transport. The SUMPs adopted by the Metropolitan Cities of Milan and Bologna define a public transportation system articulated on four sub-systems: the arterial system, which is made up of the radial structure of the metropolitan rail system; the primary system, which is constituted by the reticular structure of the Metropolitan Rapid Transit system; the complementary system, which is formed by secondary and tertiary bus lines; and the integrative system, constituted by local, low frequency or "targeted" and/or flexible services. The improvement of the public transport system is recognised as a central aspect of sustainable urban mobility also with the adaptation strategies. Yet, the need for social distancing requires to combine the re-organization of public transport with actions aimed at the reduction and temporal redistribution of the transport demand; The adaptation strategies elaborated by the City of Milan and the City of Bologna, thus underline the need for the Reorganization of services and logistics, to reduce travel during critical hours and reduce the impact on public transportation and the road system.

The SUMPs also pursue the modal transition via the improvement of active mobility infrastructures: redesigning pedestrian and cycling routes to increase the usability of public space and assure vulnerable users' access to services, public transportation, and jobs is a central component of the SUMPs adopted by the MCMI and the MCBO.

The regeneration of the road space as a multi-functional environment is a final point to consider. Distinct conceptualisations of the road and pedestrian spaces are revealed in the selected SUMPs. The Metropolitan City of Milan's SUMP focuses primarily on creating a system of safe pedestrian itineraries to ease access to the Public Transportation System's nodes. As a result, pedestrian spaces are conceived as mobility infrastructure, set within policies to improve public transportation accessibility and attractiveness. Vice versa, The SUMP of the Metropolitan City of Bologna embodies the concept of road space as a multi-functional, vibrant public space that integrates economic, transportation, social, and ecological functions.

Considering the measures contained in the SUMPs and in Metropolitan and urban strategic plans, the Municipalities of Milan and Bologna elaborate a set of adaptation strategies for re-organising public spaces and mobility based on the need for social distancing and of the radical modification of social and individual practices related to the coronavirus. The aim is to define rapid solutions for social through reconfiguration of areas and modes of transportation, with the goal of achieving long-term benefits, such as improved local mobility and relations, increased quality and quantity of distributed public spaces and pollution reduction.

In particular, the emergency plan for cycle mobility formulated by the Municipality of Bologna focuses on two types of actions: Interventions that can be realised rapidly and at a modest cost; and the anticipated completion of interventions related to the creation of segments of the leading cycling routes system. As a result, the actions proposed to focus on three aspects: i) construction of a strategic system of itineraries along important roads coinciding with the lines of the desire of users and integrated into the metropolitan system; ii) the construction of recognisable, continuous, safe, attractive itineraries; iii) the creation of an integrative cycling system, environmental islands and moderate traffic

areas to ensure equal conditions of safety, and to integrate local routes into the strategic system. Moreover, the plan for pedestrian mobility aims to improve pedestrian usability in all districts of the urban area via a system of micro-interventions that actualise a polycentric and sustainable urban model. The plan identifies three actions: i) creation of Pedestrian spaces near educational facilities via agile interventions of Ground painting, the transformation of lanes or parking lots into pedestrian zones, an extension of pavements, and insertion of seats and vegetation; ii) Design of playgrounds in pedestrianised paved areas; iii) Actions of urban regeneration based on interventions aiming at acquiring new spaces for socialisation, recreational activities, and trading in poorly managed road areas. The aim is, thus, to reduce the environmental impact of the built environment and improve the functional and architectural quality of the urban space. The Adaptation Strategies proposed by the City of Milan reveal a similar perspective and focus on specific criticalities of the SUMP, particularly on the absence of measures aimed at coordinating urban and transport planning and on the conceptualisation of pedestrian spaces as mere mobility infrastructures. As a result, the Adaptation strategies propose strategies to reduce the demand for long-distance trips. These strategies include: i) increasing the availability of local public services to ensure the availability of fundamental services by a 15-min trip on foot; the aim is to balance the inequalities among districts and reduce inter-district travels; ii) creating local clinics, starting from low-income, densely-populated areas and areas with a higher number of elderly citizens; iii) promoting an increasingly widespread cultural structure, versus a condensed and centralised cultural model: a widespread culture not only in terms of genres and target audience but, above all, in terms of availability and distribution (Table 1).

Table 1. Results of the comparative content analysis for the SUMP of Milan and Bologna

Category	Milan		Bologna	
	SUMP	Adaptation strategies	SUMP	emergency plan
Road infrastructure	Amelioration of existing infrastructures; Construction of Local Variants; Redesign of intersections to reduce conflict among road uses		Re-design of road edges as ecological buffer zones	

(*continued*)

Table 1. (*continued*)

Category	Milan		Bologna	
	SUMP	Adaptation strategies	SUMP	emergency plan
Pedestrian cycling infrastructure	Completion of a metropolitan system of direct, safe, continuous, legible, recognisable cycle routes integrated into regional and national systems; Safe pedestrian routes;	Project "Strade Aperte" + developing tactical urban planning projects and extended cycle network; Adapting the sidewalks to physical distancing requirements; Creating temporary pedestrian areas in districts lacking green spaces; Encouraging local bars and restaurants to create outdoor seating areas	Completion of a metropolitan system of direct, safe, continuous, legible, recognisable cycle routes integrated into regional and national systems; Construction of a continuous, trans-scalar structure of pedestrian areas, temporary pedestrian areas, Privileged pedestrian Transit areas, dedicated routes, and improvement of conditions of pedestrian fruition across the entire system of roads	Rapid and economic Interventions and anticipated completion of interventions for; i) construction of a strategic system of cycling itineraries along important roads; ii) the construction of recognisable, continuous, safe itineraries; iii) the creation of an integrative cycling system; Identification of potential district centralities to be qualified as areas with a predominant pedestrian vocation; Interventions for creating distributed pedestrian areas, including i) Pedestrian spaces near educational facilities; ii) Ground games on previously pedestrianised paved areas; iii) Urban regeneration

(*continued*)

Table 1. (*continued*)

Category	Milan		Bologna	
	SUMP	Adaptation strategies	SUMP	emergency plan
Public transport	From the radial configuration of public transport to a reticular structure; Integration of distinct modes of public transport into a multi-level system; Design the nodes of the Metropolitan public transport system as centralities of the metropolitan area;	Improving and diversifying mobility services; Limiting the number of people using PT;	From the radial configuration of public transport to a reticular structure; Integration of distinct modes of public transport into a multi-level system; Design the nodes of the Metropolitan public transport system as centralities of the metropolitan area	
Circulation	Valorisation of actions of mobility management; Promotion of free flow and station-based shared mobility and micro-mobility	Adapting Time Plan of public services; Promote remote learning + smart and remote work models; Mobility as a Service model; Promoting shared mobility solutions Reorganising delivery logistics by encouraging them to "buy local."	Valorisation of actions of mobility management; Promotion of free flow and station-based shared mobility and micro-mobility	Reorganise offices, enterprises, public services, and logistics to restrict travel during peak hours;

(*continued*)

Table 1. (*continued*)

Category	Milan		Bologna	
	SUMP	Adaptation strategies	SUMP	emergency plan
Urban form	Verification of impacts of planned settlements on demand for mobility;	Increasing the availability of public services in the district, implementing the 15-min city model; Creating local clinics; Promoting a widespread cultural system	Verification of impacts of planned settlements on demand for mobility; Increase in building density and of the diversity of Land Uses in areas adjacent to MRS nodes and intermodal centres; Limiting dispersed urbanisation; Re-locating the building capacity of rural areas in urban areas presents a good provision of services and public transport infrastructures	

Moreover, the adaptation strategies incorporate a conceptualisation of roads and pedestrian surfaces as places for socialisation that integrates the measures to promote active mobility. More precisely, besides actions aimed at reducing car spaces, implementing 30 km/h zones, and realising a continuous system of pedestrian and cycle routes along the main routes - such as San Babila Square, Buenos Aires Boulevard, Monza Boulevard and Sesto Marelli Boulevard - the adaptation strategies include a set of actions of re-configuration and re-organization of road spaces. These actions have five forms of interventions: i) the realisation of the Project "Strade Aperte" and the development of residential roads; ii) the adaptation of pedestrian surfaces to social distancing requirements and the identification of "protected" routes for vulnerable individuals; iii) the extension of public spaces creating temporary pedestrian areas in districts lacking green areas, to promote children's independent outdoor activities (Play Streets); iv) the realisation of open squares in every district: Developing large-scale tactical urbanism projects to promote pedestrianisation, particularly around educational facilities, amenities and in districts with fewer green areas, to provide spaces for children to exercise and play; v) the creation of outdoor spaces for the service industry, extension of seating space for bars and restaurants on pavements, or as replacement of parking spaces.

Thus, the measures adopted by the City of Milan and by the City of Bologna for the post-pandemic scenario can delineate a set of transferable strategies to provide long-term benefits and a radical re-organization of the urban environment for the post-pandemic scenario. Building on the results of the comparative analysis, a set of guidelines for the Metropolitan City of Cagliari is presented in the subsequent section.

5 Discussion and Conclusions

A set of general considerations related to the impact of Covid-19 on urban policies emerges from the results of the comparative content analysis: the first consideration concerns the effects of the pandemic on urban governance and policies in terms of the need to adopt strategic plans for the post-pandemic scenario. The second aspect regards the emerging need to coordinate urban and mobility planning related dimensions. The last consideration concerns the radical re-conceptualization of specific components of the built environment due to the modification of individual and social practices determined by the pandemic. This aspect is particularly evident in the distinct conceptualisation of pedestrian spaces in the SUMP and in the adaptation strategies of the City of Milan: from an understanding of pedestrian spaces as infrastructures of active mobility to multifunctional places for sociality and recreational activities. The results of the analysis of the SUMPs and of related adaptation strategies are a valid starting point for the definition of a set of guidelines for the drafting of the SUMP of the Metropolitan City of Cagliari. A first aspect concerns the centrality of strategies aimed at reducing the demand for long-distance trips, including i) re-organization of the infrastructure of services and urban functions based on the 15-min city; ii) limiting dispersed urbanisation by locating interventions of urban development along the edge of densely urbanised areas and presenting a significant density and diversity of services. A central aspect of policies for sustainable mobility in the metropolitan city of Cagliari regards the radical reorganisation of public transport to favour a modal transition and realise a more balanced modal split. The fundamental strategies include:

i) developing a reticular strategic system of interurban and metropolitan itineraries for rapid mobility services - train, Light Rail System (LRS), Bus Rapid Transit (BRT); ii) developing a distribution system consisting of local bus lines; the strategic system, in particular, includes the radial itineraries aimed at serving the transport demand convergent on the urban area of Cagliari and transversal and tangential itineraries aimed at serving inter-municipal trips in suburban areas and trips converging on the centralities emerging in the areas of dispersed urbanisation, along with the main road infrastructures; iii) creating an integrative system, based on shared mobility services local, low frequency or "targeted" and/or flexible services and Demand responsive transport services (DRT). In particular, DRT services are central to serve the demand for mobility originating in marginal areas and in areas of dispersed urbanisation.

A second aspect regards the need to coordinate actions aimed at improving the level of service of public transport and actions of mobility management aimed at re-organizing the temporal distribution of the transport demand as a fundamental requirement for favouring the modal transition from private transport to sustainable forms of mobility; as a consequence, the organisation of a multi-modal, multi-level transport system, based on a grid configuration, is to be supported by the re-organization of timetables of public services – particularly social and educational services - and productive activities to avoid overlaps in entry and exit times, regulate the demand for mobility and facilitate social distancing. The redevelopment of train and MetroCagliari stations as intermodal centres and as multifunctional spaces, including services and amenities, constitutes a central aspect of actions aimed at the improvement of public transport and at connecting public transport and the urban landscape [34]. Moreover, a relevant consideration concerns the development of a continuous, pervasive metropolitan-scale infrastructure of pedestrian and cycling routes and its integration with the infrastructure of public transport: A central requirement for the project and integration of these infrastructural systems is to connect the emerging centralities located in the suburban areas, along with main transport infrastructures, and the dense and compact urbanised districts.

The last consideration concerns the qualification of road spaces as multifunctional spaces, integrating the transport and social and ecological functions. As a consequence, large-scale tactical urbanism interventions, focusing on the development of usable public spaces, in particular in areas presenting scarcity of green areas, is a fundamental aspect of policies aimed at promoting sociality, inclusion and independent activities of the vulnerable users, in every district of the metropolitan city [34–36]. These strategies are to be complemented by measures to reduce on-street parking spaces, and the incidence of private motorised transport along local roads, by implementing car-free districts and Local Environmental Areas. Consequently, a model of the organisation of the mobility system emerges based on the pre-eminent function of public transport and active mobility in serving the transport demand, and on the complementary role of motorised private transport. This organisation of mobility can result in a radical re-organization of the metropolitan city, based on the abstract grid, the supervillains and on the 15-min city models; these models can be summarised in a four principles structure; the qualification of districts as urban units, presenting significant density and diversity of services and functions; the requalification of local roads as spaces for active mobility and for

optional-recreational and social activities; the concentration of residual motorised transport on distribution roads tangential to urban districts, and the development of protected Public transport itineraries, that intersect pedestrian and cycle routes, and that constitute the infrastructure for inter-districts and inter-municipal movements. The implementation of the proposed strategies, and the definition of a set of specific, measurable, realistic and time-bound objectives, to monitor the impact of adopted actions are thus central to facilitate the transition to a development model that realises the objectives of resilience, environmental sustainability, social inclusion, economic development and protection, of urbanised areas, from environmental and health concerns. In this regard, the research underlines that the sustainable mobility model is not resolved by the mere decarbonisation of the transport sector. Nonetheless, it mainly results from the integration of participative practices [38–41] with actions aimed at reorganising the distribution of services and amenities, and of building density, and at re-configuring transport infrastructures. In particular, preventing dispersed urbanisation, promoting the regeneration of suburbs, increasing the density and diversity of functions, developing public transport strategic and distribution itineraries to serve inter-municipal travels, improving the usability of public spaces and creating a continuous and pervasive infrastructure for active mobility emerge as the central strategies to meet the requirements of salubrity, sustainability, resilience, universal access, and to accommodate the new lifestyles resulting from the pandemic.

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