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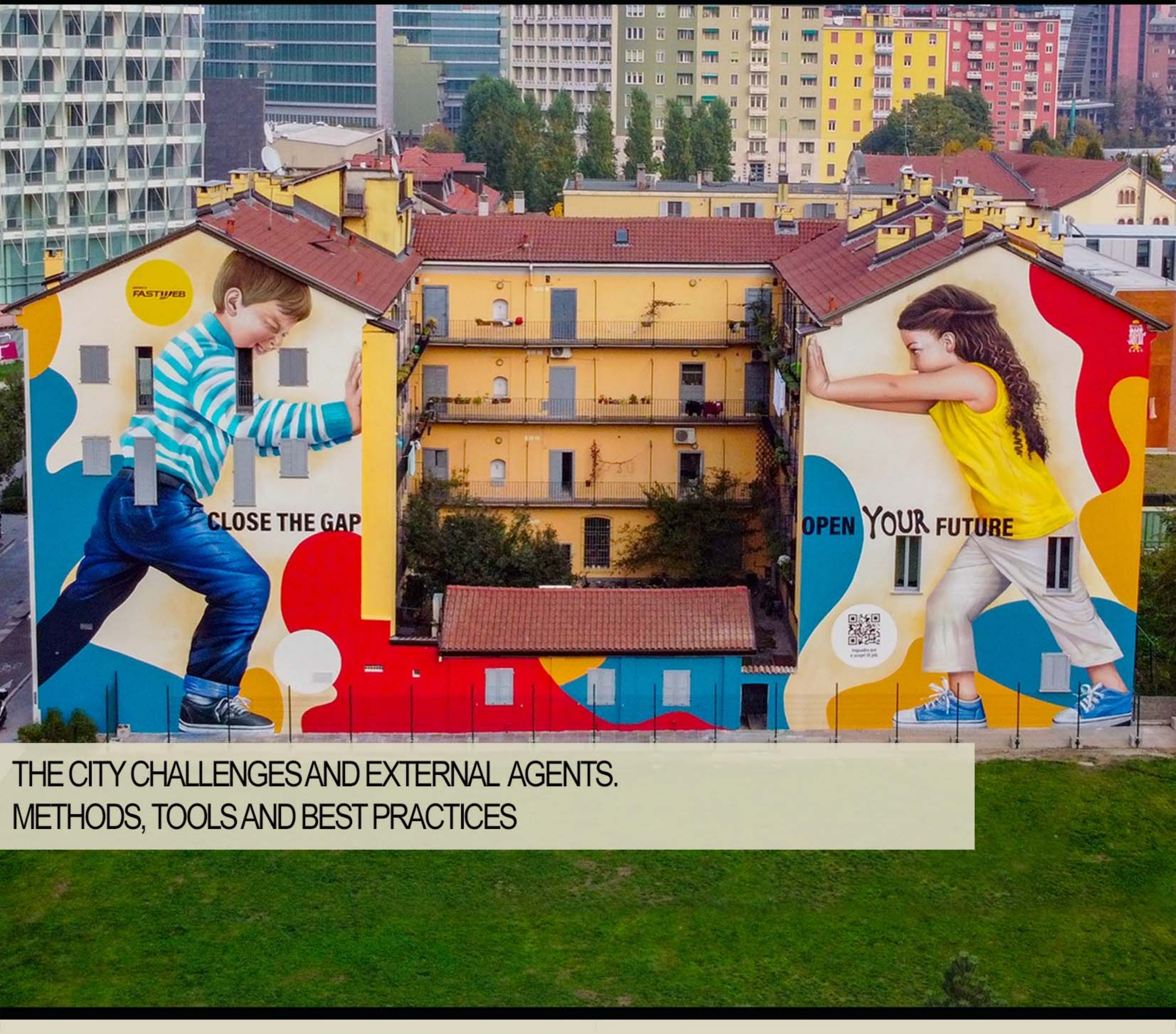

THE CITY CHALLENGES AND EXTERNAL AGENTS. METHODS, TOOLS AND BEST PRACTICES

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The cover image shows redeveloped building in the Garibaldi neighbourhood in the city of Milano (Picture by Fastweb, retrieved from: https://www.facebook.com/Fastweb/photos/10158794132149472).

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A sustainable approach for planning of urban pedestrian routes and footpaths in a pandemic scenario. Evidence from Italian cities

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Abstract
The coronavirus (COVID-19) pandemic has forced national and local governments to reconsider the relation between mobility, urban space, and public health, in order to ensure physical distancing while meeting the travel needs of inhabitants. Limitations associated with the perceived risk of infection influenced significantly travel behaviours, pushing a modal repositioning in demand to active mobility (walking, cycling, and use of micro-mobility). On the other hand, the World Health Organization (WHO) guidelines on mobility during the COVID outbreak are mostly directed at dedicating more urban space to cyclists and pedestrians, especially in densely populated urban areas, with the intended aim of avoiding crowding on public transport, or the use of private cars as an alternative. The National Association of City Transportation Officials (NACTO, 2020) went in the same direction. In the given conditions, walking became predominant for a sustainable mobility scenario, and structural measures (as widening of pathways) or regulatory measures (as the regulation of pedestrian flows) can be adopted withing the given strategy. Current pedestrian infrastructural offer is severely limited in functional terms by urban planning and development, therefore measures oriented to enhance non-motorized mobility require firstly the development and planning of new public spaces and infrastructures for pedestrian mobility within the urban layout. Policy makers and town planners need to rethink urban spaces and mobility in a pedestrian perspective. A methodology for the classification of pathways, by capacity and level of service, is presented, which can be used to verify pedestrian mobility demand for specific measures, strategies, and policies.

Keywords
Social distancing; Pedestrian behaviour; Level of service; Pedestrian infrastructures; Walkability.

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1. Introduction

The coronavirus disease (COVID-19) pandemic has fundamentally changed lifestyles and habits, and it is likely to have lasting effects on our society. Everyday life has been strongly influenced by safety measures introduced as social distancing, also called "physical distancing," which consists in keeping a safe space between yourself and other people from a different household. All the measures taken have generated a number of serious social and economic implications in all fields, including transport, travel, and mobility (Anastasiadou et al., 2021; Cieśla et al., 2021; Paydar and Kamani Fard, 2021; Fenu, 2021, Jones et al., 2021; Vittelo, et al., 2021). The state of emergency has obliged governments to prohibit "unnecessary" circulation, and to restrain mobility, limited to essential workers and goods, for the sake of public health and to contain the propagation of the virus.

In Italy restrictions on public transport were enforced from the 9th of March 2020, enforcing limitations on vehicle occupation, on private and public transport where a limit on 50% of all seats per vehicle was introduced. Restrictions included limitations in numbers for passengers also on platforms and transit spaces.

Fear of infection and perceived risk also significantly influence travel behaviours, particularly for transit use, and the influence varied based on the infected area and demographic characteristics of the people (Kim et al., 2017, Cahyanto et al., 2016).

The National Association of City Transportation Officials (NACTO, 2020) highlighted that during periods of stabilization and long-term recovery, when restrictions are relaxed and businesses are starting to re-open but the risk of infection is still present, cities will need to focus on how to help people maintain physical distance while moving around the city. As shown by Paydar and Kamani Fard (2021), many cities around the world have expanded their cycling/walking infrastructures to increase their resilience in the face of the COVID-19 pandemic. Furthermore, the benefits of active urban mobility never as during such last year have been seen as a topic to push city users towards a more sustainable mobility style. Active urban mobility benefit individuals through reduced health care costs, and therefore benefits authorities by reducing health care expenses. Research results indicate that every kilometre travelled by car in EU countries, in relation to the costs associated with the treatment of diseases caused by pollution, accident risk assessment, et sim., costs society € 0.15 on average, whereas every kilometre travelled by cycling, or walking, benefits society in the form of € 0.16 thanks to the improvement of public health and the absence of the negative effects associated with car use (UNECE, 2020). Therefore, the opportunity to have a methodology for analysing pedestrian routes as well as to identify footpaths emerges. It can be a useful tool for cities proposing attractive travel options different than cars, and can put the basis for a more resilient urban transport system.

The pandemic scenario and the related containment measures have substantially impacted on the perception of safety on people, and particularly on Public Transport users, even influencing travel mode choice (e.g., De Vos, 2020; Isfort,2021). For example, in Italy, the analysis of modal repositioning in demand after the lockdown shows that pedestrian mobility has captured 23.4% of trips out of public transport and 41.3% of private vehicle/car. Also, in 2020 the proximity demand marks a peak, shorter journeys (less than 5 minutes on foot) have gone from 6% in 2019 up to 17% in the lockdown period, reassessing on 10% in the following months (Isfort, 2020).

Even if this were to be only a temporal situation, given the great uncertainty on the duration, we can expect that active mobility (walking, bicycles, micro-mobility) has an opportunity to grow steadily in the modal share during this period: people have already experienced healthier, less expensive and environmentally friendly solutions for getting around and have rediscovered the value of territorial proximity (Isfort, 2020).

It is therefore clear that Walkability – intended as "the extent to which the built environment supports and encourages walking by providing for the pedestrian's comfort and safety, connecting people with varied destinations within a reasonable amount of time and effort, and offering visual interest in journeys throughout the network"–should assume a relevant role on the cities' mobility (Southworth, 2005; Cirianni et al., 2018; Comi, 2021; Comi et al., 2022).

It is not infrequent that walking is the "last mile" mode in multimodal trips, assuming a main role in the transport system assessment for quality as perceived by the users. "The last mile" is a term used in transportation planning to describe trips of people and goods from a transportation hub (railway station, bus depot, ferry slip, etc.) to a final destination (home, work, etc.) (Goodman et al. 2005; Cirianni et al., 2021). It is known that in many cities users have, in standard conditions, difficulty getting from their starting location to a transportation network and vice-versa, in relation to the low quality and functional characteristics of the pedestrian infrastructure. In this situation the "physical distancing" could further minimize the quality of service of the pedestrian walkways, which should guarantee a safety standard for all users, whether walking as the main mode of transport, or as a means of access to other modes.

However, it is quite clear that the term "safety", is used with two different ways - in the most common sense of road safety, in preventing pedestrians from road accidents, and in the wider health prevention given by the exposure to risk of covid contagion.

In order to provide safe mobility while maintaining distance, wide and accessible road spaces are needed for all city residents (Comi et al., 2019; Nuzzolo et al., 2019; Rakhmatulloh et.al., 2020; Comi et al., 2022). The pedestrian walkways should be part of a network with appropriate level of service and safety on all the sections of the route, taking into account the needs of all potential users.

Therefore, in the short term the focus is to manage and regulate infrastructure, and in the medium/long term to plan streets and public spaces so to rethink and to guarantee spatial capacity standards for potential demand.

The present paper, using an Italian case, introduces traditional approaches, as found in literature, to define design criteria and indicators for pedestrian pathways (Section 2). The authors intent to present an analysis of the influence of the new parameters, related to the measures as social distancing, on traditional approaches. Then, an application to the Italian cities is presented (Section 3). Section 4 reviews the impact of social distancing on the existing infrastructure. Then, on the basis of the results, a set of measures are suggested in order to provide sustainable short-term urban mobility and transport planning interventions in order to plan a smart pedestrian network (e.g., increase of infrastructure capacity, flows and queue management, information to users by technology, etc.; Section 5). Finally, conclusions are presented along with policy implications and limitations (Section 6).

2. Design criteria and indicators for pedestrian pathways

A walkable network has several of important attributes including safety, both from traffic and social crime, the quality of path, including width, paving, landscaping, signing, and lighting, etc.. The ideal pedestrian path will provide for the comfort and safety of pedestrians of varied ages and physical abilities (Southworth, M., 2005). According to Lian et al. (2021), attractiveness seems to play an essential role in improving urban vitality and is highly correlated with urban redevelopment.

In particular, a walkable neighborhood can encourage active walking behaviour (Saelens et al., 2008) and generate active street life (Speck, 2013). Some studies show that the presence, proximity, and quality of the attractive destinations can play a key-role in stimulating walking activities (Sugiyama et al., 2010; Giles-Corti et al., 2005). Moreover, less traffic volume and lower speed (Appleyard, 1980), presence of service or stores (Jia et al., 2014), and visual enclosure (Wang et al., 2019) are supporting evidence. Many studies identify characteristics of the built environment that are associated with physical activity, particularly emphasizing walking as a widespread population-level means of getting physical activity (see Dalmat et al., 2021 and references therein quoted).

In this sense the separation of the pedestrian from motorized traffic is an essential design feature of a safe and functional multimodal roadway. Sidewalks, pathways, footpaths are all facilities for pedestrian traffic.
The framework in which criteria and indicators proposed are developed, are directly related to the approach of safety and user classification.
Common to all research in the field of road design, whatever the mobility mode involved is the prioritization safety for users, and in this are included policies of modal priority for road users, particularly in urban areas, the hierarchy being based on safety, vulnerability and sustainability. Walking should be at the top of the hierarchy, followed by cycling and use of public transport. The indicator which is mostly adopted to assess pedestrian facilities and give a measure of the comfortability level of them is the Level of Service (LOS), as defined in the LOS approach (Sing and Jain, 2011, Frazila et. al., 2019, Bansal et.al., 2020). The LOS approach describes the existing conditions and allows a qualitative measure to relate the quality of traffic service (Asadi-Shekari et al., 2012).
The advantage of such approach it is that it measures multiple facets: customer satisfaction, environmental requirements and legal requirements (Raad N., Burke M., 2017). The approach for pedestrian facilities is in relation to the approach used to analyze roadways and intersections by categorizing traffic flow and assigning quality levels of traffic (HCM, 2020).
Pedestrian facilities can be classified in two classes: uninterrupted and interrupted. Uninterrupted pedestrian facilities include sidewalks, walkways, stairways and queueing areas, while interrupted facilities are crosswalks, which are further categorized into signalized intersections, un-signalized intersections and midblock crosswalks. The LOS thresholds for each category are different, but all are based on the concept of special occupation per pedestrian, which is a measure of pedestrian comfort and mobility. The combination of footways (sidewalks) beside carriageways and dedicated crossing points identifies a route in which pedestrians have a dedicated right of way.
The level of service (LOS) for pedestrian facilities has been defined on the basis of capacity and pedestrian volume. Factors like personal body shape, type of flow and dimensions of pedestrians have been considered in order to define service levels (Fruin, 1971).

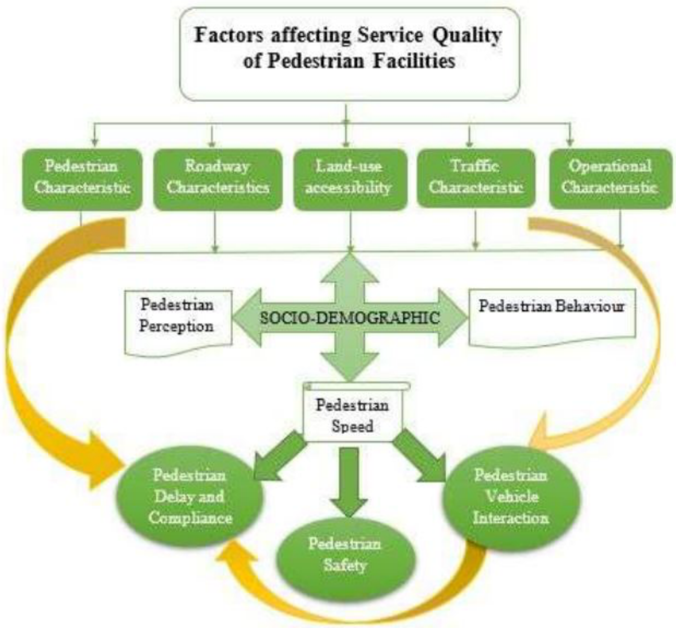

Fig.1 Interdependence among various factors influencing LOS (Source: Bansal and Goyal, 2018)

In the course of time, the definition of LOS has evolved and modified many times so as to incorporate new factors such as freedom to manoeuvre, traffic interruptions, comfort, and convenience. The literature suggests

that the quantitative approach alone for evaluating the LOS is insufficient to find the appropriate results and the qualitative factors which contribute significantly in the analysis of pedestrian LOS (Bansal and Goyal, 2018). Pedestrian perception and behaviour are linked to socio-demographic variables (gender, age of pedestrians, education, employment etc.) which are, as shown in Fig.1, in turn interrelated to each other by numerous factors, such as pedestrian flow, pedestrian density, area occupancy, speed, walkway/sidewalk width, presence of obstacles, walkable area, land-use accessibility, etc.
The set of characteristics which affect the service quality of the pedestrian facilities, are interdependent with the indicators which define the Level of Service. Therefore, there is a bidirectional relation between the behaviour, speed and perception of the pedestrian flow and the accessibility, operational and traffic characteristics, which varies in function of the sociodemographic parameters, and in relation to user behaviours.
Furthermore, the variation in the quality of service affects the pedestrian facility factors. In the present infrastructural scenario, in which most streets and sidewalks are not designed on the basis of pedestrian demand, nor in function of the design capacity, qualitative factors mentioned in the introduction, as fear of infection and perceived risk, will further affect the perception of the facilities quality.
The first space parameter which could be affected from the "physical distancing" is the effective walkway width defined as the portion of a walkway that can be used effectively by pedestrians.
Effective walkway width is the portion of a walkway that can be used effectively by pedestrians. Various types of obstructions and linear features, discussed below, reduce the walkway area that can be effectively used by pedestrians. Fixed objects can be continuous such as a fence or a building and also can be discontinuous like trees, poles or benches.
The effective walkway width at a given point along the walkway is computed as follows:

$$W_E = W_T - W_O \quad (1)$$

- W_E= effective walkway width,
- W_T= total walkway width at a given point along walkway,
- W_O= sum of fixed object effective widths and linear feature shy distances at a given point along the walkway.

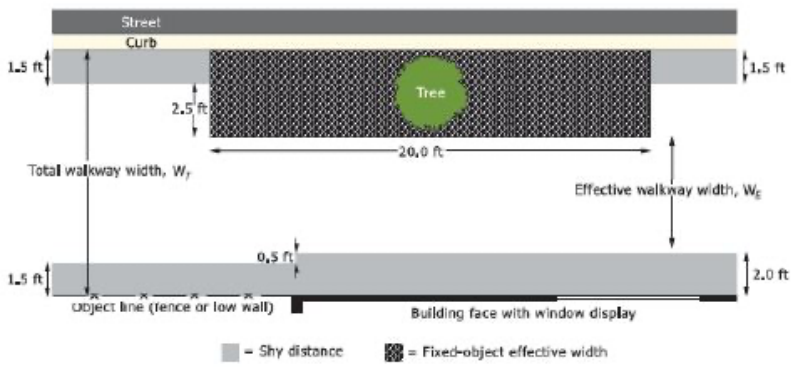

Fig.2 Instructions for calculating effective sidewalk width (Source: HCM 2010 Exhibit 17-17)

The Highway Capacity Manual (HCM, 2020) provides a function to calculate effective sidewalk width in account of fixed objects and shy distances, as shown in Figure 2. The shy distance on the inside (curb side) of the sidewalk is calculated measuring from the outside edge of the paved roadway or face of curb, if it exists (generally, considered to be 1.5ft/0.45 m). Shy distance on the outside of the sidewalk is considered 1.5 ft/0,45 m if a fence or low wall exists. If a building is present, it is considered to be 2.0 ft./060 m, if window

display exists 3.0 ft./0.90 m, otherwise it is 0.0 ft/ 0 m Other sources consider more fixed objects as street lamps (0.70 – 1.0m), traffic signs (0.60-0.70 m), fire hydrant (0.70-0.90 m), (Brilon et al., 1994).
The HCM states that effective sidewalk width is an average value (HCM,2020). The above-mentioned shy distances value is obtained by observing the pedestrian's behaviour by walking on different type of facilities and flow conditions. It has been confirmed that the pedestrians keep a certain distance from other pedestrians and from the edges of roads, walls or obstacles. This distance is reduced in the case of hurry or density increasing (Helbing et al., 2001).

3. Application to sidewalks in Italian Cities

If compared to the sidewalk dimensions in most Italian cities, it can be observed that in average the given shy distances aren't respected. Furthermore, it is not an adopted practice in path-way design to have planting strips between the sidewalk and the curb.
With regards to sidewalk dimensions the Italian law sets the minimum obstacle free sidewalk width in 1.50 m, which becomes 2.00 m in the case of the presence of newsstands, bus stops or similar (D.M. n. 236 14/06/1989, D.M. 05/11/2001).
Common guidelines indication is that the pedestrian zone must provide continuous clear space for walking and be entirely free of obstacles. It is well known that the curb dimensions near a crosswalk will substantially influence the waiting area in term of square meters available per person.
The above-mentioned regulatory instructions have been applied for roads and areas built after the adoption of the regulations, but it is not unusual that the functional and dimensional requirements of pedestrian facilities differ significantly, and also of a critical amount. In central districts and adjacent areas, the sidewalks quite often have a width inferior to 1.50 m. In Figure 3, examples of sidewalk in consolidated residential areas, where total effective width is less than 1.00 m. In this case walking width is limited to a single person, without bags or bulk and, and there isn't space for another pedestrian coming in the opposite direction who often must walk on the road.
The minimum widths prescribed by legislation doesn't appear sufficient to guarantee in peak conditions a comfortable outflow. A width of 5.0 ft/1.50 m o is the bare minimum required for two people in a line. Technical regulations in USA prescribe for locations as schools, sporting complexes, leisure parks, and shopping districts, a minimum width for a sidewalk of 8.0 ft/ 2.40 m (FHWA, 2006).
It follows that if by comparing the space occupied by a person, given the need of physical distance from other people and street obstacles, and the effective width a on pedestrian infrastructures, it is foreseeable that unregulated pathway flows are subject to congestion and flow disruption.
The minimum required distance kept between people for comfort is defined Personal space (or personal distance), and it ranges from a minimum of 45 to 120 cm, corresponding to an arm length. In free flow conditions people try to keep this distance from others, allowing this distance to reduce for people in close relationship. If personal space is invaded without consent it causes people to feel uncomfortable (Frohnwieser, 2012). The Italian Technical Fire Prevention Standards assume a value for the medium size person which is is identified as an elliptical surface, vertical projection of the human body, having the major axis equal to 60 cm and the minor axis equal to 45 cm. This ellipse encloses an area of 0.218 m^2. Other bibliographic sources. recommends a simplified body ellipse of 50 cm x 60 cm for standing areas, with a total area of 0.30 m^2 as standing buffer zone, and of 0.75 m^2 as walking buffer zone. (HCM, 2010).
If we assume two people moving in the opposite direction without any bags and add the above minimum values of shy distance (W_O), personal distance (W_D) and person size (W_P), we get a sidewalk width $W_E = W_O + W_P + W_D + W_P + W_O$ = (0.45 m + 0.60 m + 0.45 m + 0.60 m + 0.45 m) = 2.55 m, which is larger than the Italian standard width. It should be however considered that pedestrians, in a standard situation, like to

keep a certain distance between each other and change their walking speed to maintain those distances. They are also very good in finding the fastest path through a field of obstacles (Frohnwieser, 2012).

Fig.3 A frequent sidewalk type with bidirectional flow in non-renewal residential area of Potenza, a medium-size regional capital of a City of South Italy region, infrastructure characterized by a width just enough the walking of just one person

4. The impact of social distancing on the existing infrastructure

Taking into account the preventive measures taken to stop the COVID-19 spread by authorities around the world, where different protocols have been adopted to restrict the turnout at diverse venues such as markets, public venues or even crowded open air places (streets, squares, beaches, and so on). This social distance is country-specific and it ranges from 1.00 m (e.g. China and France), as recommended by WHO, up to 2.00 m (e.g. UK and Canada), being 1.50 m in the Netherlands. In USA physical distancing guidelines recommend a distance of at least 6 feet (1.80m, about 2 arm lengths) from other cyclists or pedestrians who are not from your household (Centre for Disease Control and Prevention, 2020).

If we assume the smallest value of the above social distances given, namely 1.00 m, and use it as interpersonal shy distance in the given formula, the result is a sidewalk width of about 3.10 m (0.45 m + 0.60 m + 1.00 m + 0.60 m + 0.45 m), in absence of fixed obstacles. If we assume that the pedestrians walk keeping a distance of 1.00 m from each other in the travel direction, the space needed per person is about 2.05 square meters.

Taking in account the space of 2.05 sq. mt, and the LOS given in Table 1 and represented in figure 4, it can be assumed that to walk safely as limit is required level D (low comfort, flow that can start to be unstable).

In Table 1, the level of service is related to the pedestrian speed in meters per minute (in a rage which varies between 2.7 km/h and 4.7 km/h), the pedestrian flow rate (per minute) for unitary width in meters. Therefore, the flow rate is given multiplying the unitary rate by the width of the sidewalk/pedestrian infrastructure in meters. The assumed space occupied by a pedestrian, which is the reverse of the pedestrian density, and the range of the ratio between pedestrian flow and capacity. Although slope could influence the walking speed, due to the low values of pedestrian, it is not fully considered in the capacity HCM (2020), opened the road for further improvement.

LOS	**Speed** [m/min]	**Unit width flow rate** [ped/min/m]	**Space** [m²/ped]	*v/c* **ratio**
A	> 78	≤ 16	> 5.60	≤ 0.21
B	> 76 - 78	> 16 - 23	> 3.70 - 5.60	> 0.20 - 0.31
C	> 73 - 76	> 23 - 33	> 2.20 - 3.70	> 0.31 - 0.44
D	> 68 - 73	> 33 - 49	> 1.40 - 2.20	> 0.44 - 0.65
E	> 45 - 68	> 49 - 75	> 0.75 - 1.40	> 0.65 - 1.00
F	≤ 45	varies	≤ 0.75	varies

Tab.1 Pedestrian levels of service boundaries on sidewalk (adapted from the HCM 2010)

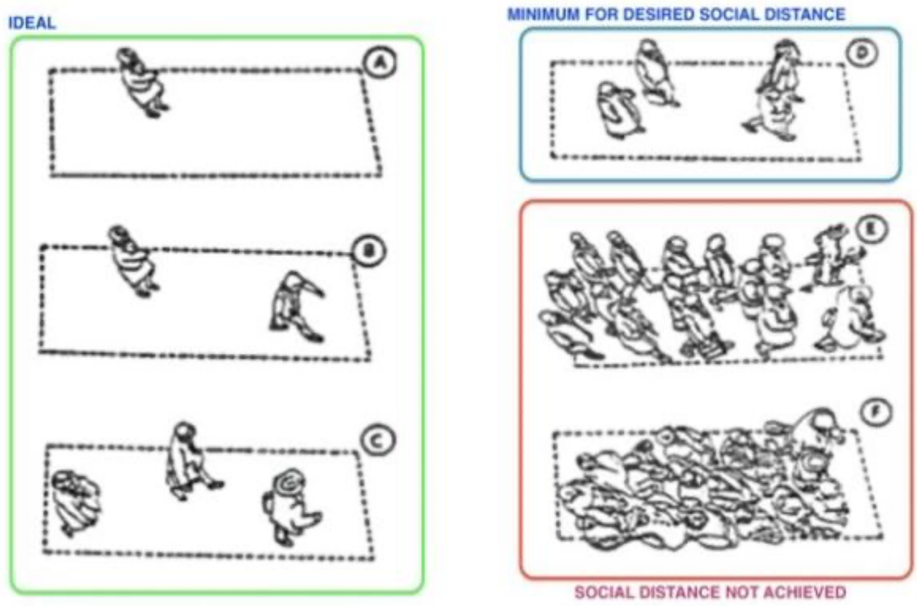

Fig.4 Minimum pedestrian spacing, ideal spacing and situations when the desired social distance is not achieved, referred to the LOS (Source: https://d0ctrine.com/2020/03/14/level-of-service-los-and-social-distance-for-pedestrians/)

The pedestrian unit flow rate is related to pedestrian space as follow:

$$V_P = \frac{S_P}{A_P} \qquad (2)$$

- V_P = pedestrian flow per unit width (ped/m/min).
- A_P = pedestrian space (m²/ped), and
- S_P = pedestrian speed (m/min)

Therefore, by using *eq. 2* and the average values of the pedestrian speed and pedestrian space of LOS D, p S_P = 70.5 m/min and A_P = 1.80 m²/ped, the associated maximum flow is approximately 2,350 ped/m/h, that for an effective sidewalk width of 3.00 m is equivalent to 7,050 ped/h, therefore a width of 1.50 m comes to 3,525 ped/h (in this case all movements in a single direction). In the same way the maximum pedestrian flow in LOS F, assuming the limit values of the pedestrian speed and pedestrian space, SP =45 m/min and A_P = 0.75 m²/ped, the associated maximum flow is approximately 3,600 ped/m/h, that for an effective sidewalk width of 3.00 m is equivalent to 10,800 ped/h, and t for a width of 1.50 m is to 5,400 ped/h. The maximum flow value of 2,350 ped/m/h is intended as the number of people per hour in both directions associated with a LOS D, and in compliance with the minimum social distance rules, it is almost 65 % of the flow value related to LOS F, equal to 3,600 ped/m/h. When sidewalks are narrower than the minimum recommended social distance between two or more people it is difficult to maintain the distance. Compliance with the social distance restricts, when sidewalks are narrower than the minimum recommended distance between two or more people, the freedom of people to move in the presence of other pedestrians easily, not only jay walking has to be excluded, but flows are conditioned, and walking faster or change their direction to greater degrees may represent a violation of social distance. An analysis was conducted in order to assess the feasibility of safety distances for COVID19 on Italian sidewalks, based on the width of many Italian cities' sidewalks data set out on information and maps available in the national Open Data Portal. The project, that is an adaptation of the work done on New York (https://www.sidewalkwidths.nyc), aimed to identify safe pathways and support intervention policies. The project. This processed map drawn in the portal shows the width of the pedestrian spaces, of those cities which have shared the data, and a classification that identifies critical spaces in which social distancing is not applicable (https://rivistageomedia.it/2020052016888/Dati-geografici/mappa-della-larghezza-dei-marciapiedi-italiani-dagli-open-data). The classification worked out in order to identify critical infrastructures indicates, in relation to the sidewalk width, the level of difficulty in maintaining social distance:

- very difficult (minus 2 meters);
- difficult (between 2 and 4 meters);
- possible (between 4 and 6 meters);
- easy (between 6 and 8 meters);
- very easy (more than 8 meters).

Fig.5 Extract from the maps of Rome and Bari (Italy) (Source: https://rivistageomedia.it/2020052016888/Dati-geografici/mappa-della-larghezza-dei-marciapiedi-italiani-dagli-open-data)

In Fig.5, an extract from the maps of Rome and Bari, which show that many streets in the two cities do not provide enough space for safe physical distancing for pedestrians (corresponding to orange and red streets in the map).

Therefore, as previously highlighted, the pedestrian infrastructure network of most Italian cities is not structured for a use in safety and comfort under the pandemic circumstances.

5. Objectives, strategies, and measures for an optimal network management

In consequence of the Coronavirus pandemic, the objective of regulators is to reduce the diffusion of the virus, whilst allowing trips e travelling for primary and necessary activities.
Therefore, pedestrian trips become relevant not only for the shortest path but also the safest.
For pedestrian movements the main strategy adopted in most countries is social distancing. To fulfil this strategy the measures which can be adopted depend on:

- physical dimension of the infrastructure (pathway and lanes);
- composition and separation of pedestrian flows.

On this assumption, to fulfil the objective of reduction of the diffusion of the virus, physical measures (width of the pathway) or regulatory measures (regulation of pedestrian flows) can be adopted withing the given strategy. Many tips are given for practicing social distancing which should impact the pedestrian's behaviour, that somehow influence many of the trip's variables. The above tips could be effectively summarized into the following (Centers for Disease Control and Prevention - CDC, 2020):

- distance should be kept at Events and Gatherings: It is safer to avoid crowded places and gatherings where it may be difficult to stay at least 6 feet away from others who are not from your household. If you are in a crowded space, try to keep 6 feet (about 2 arm lengths) of space between yourself and others at all times, and wear a mask. Masks are especially important in times when physical distancing is difficult. Pay attention to any physical guides, such as tape markings on floors or signs on walls, directing attendees to remain at least 6 feet apart from each other in lines or at other times. Allow other people 6 feet of space when we pass by them in both indoor and outdoor settings;
- to stay Distanced While Being Active: Consider going for a walk, run or cycling in a neighbourhood or other safe location where at least 6 feet of distance between pedestrians and cyclists can be maintained.

Current pedestrian infrastructural offer is severely limited in functional terms, and it is clear the need to adopt measures oriented to enhance non-motorized mobility as well as the provision of public spaces and services within the city. In particular, the most widespread measures adopted in many cities are oriented to change urban streets and public spaces and enhance the residents' safety (Barbarossa, 2020). It emerges that what originally started as temporary measures, including the conversion of road space into pedestrian walkways and cycle lanes, has found widespread support and is leading to permanent infrastructure changes (UN-Habitat,2021). These types of measures as broader sidewalks, addressing urban space and alternative usage of curb sides, taken from car usage and assigned to pedestrians and cyclists (Lozzi et al., 2020). Most measures are contained in a new guide to street design for the ongoing pandemic and future recovery, released by the National Association of City Transportation Officials (NACTO). The key principles in rethinking streets and public spaces for a post pandemic city are: supporting public health guidance, considering physical distancing, increasing the outdoor space available for people, creating safer street that prioritize public transit, cycling and walking, supporting local economies and bringing communities into the process. Most of the implemented are recorded in the Shifting Streets database come from the "Local actions to support walking and cycling" dataset. This dataset, initiated and managed by Tabitha Combs and supported by the University of North Carolina's Pedestrian and Bicycle Information Center (PBIC), documents 841 actions taken by 394 cities, states, and countries between March 10 and July 15, 2020 (http://pedbikeinfo.org/shiftingstreets). Value frequencies for the above application shows that the most common application, 13% of all recorded mobility response, is reallocation of some but not all traffic lanes to walking and bicycling, followed by full and partial street closures for walking and bicycling, each with 11% of all recorded mobility responses (Combs et al., 2021) .
In synthesis, the most effective measures adopted by many cities, are:

- removing motor vehicle lanes from residential streets and extending sidewalks near shops, schools, and parks to make walking safe and enjoyable for transit and exercise.

- establishing safe cycling routes to and from schools, offices, and close to main roads, by closing roads and carriageways where necessary, so that people can have a safer alternative to private cars and public transport;
- creating safe access routes on foot and bike as well as safe public spaces and green areas at the neighbourhood scale, closing roads and squares to motorized traffic.

Figures 6 and 7 show some of the above solutions for pedestrians adopted in Milan and - Brookline (MA, USA). The type of Policies to consider in the evolving pandemic scenarios indicated by NACTO, are shown in Table 2.

All mentioned actions involving just the management of the infrastructures do not provide the efficient achievement of the objectives. In this regard the management of the whole pedestrian's system is needed, also involving the demand, and more specifically pedestrian demand. Like driver monitoring and information systems, the design and implementation of a monitoring system for pedestrian is suggested, developed using ITS. Such systems require two integrated components: a traffic monitoring system and a demand management system, connected continuously with a main data center.

The information of the two integrated sub systems should be matched and enable the "traffic manager" to monitor and control traffic in areas or corridors of high pedestrian use, and by continuously getting traffic information feedback in real time to users also to direct to alternative routes. The system should include a sub system of dynamic monitoring on the walkway density situation and real time assessment of available walkways with an acceptable LOS (level D), and dynamic information using message transfer on public and personal devices about the real-time pedestrian's density and alternative routes. The implementation of the proposed measures, with ITS systems, should be designed in order to support a Smart Pedestrian Network (SPN), promoting sustainable mobility.

The SPN system provide information on suitable walking routes aiming to satisfy potential users' needs, and reduce congestion.

Fig.6 Construction works for the new cycle lane on Corso Venezia -Milan (04/30/2020) (Source: https://www.comune.milano.it/documents/20126/7117896/Open+streets.pdf/d9be0547-1eb0-5abf-410b-a8ca97945136?t=1589195741171)

Fig.7 Brookline (MA, USA) used cones and temporary signs mounted on freestanding delineator posts to extend sidewalks and create bike lanes along four high-volume streets (Source: https://nacto.org/wp-content/uploads/2020/07/200708_Sidewalk-Extensions.pdf)

6. Conclusions

The Covid Pandemic, among its effects on the world community, has led to new patterns in transport, and measures have been adopted to reduce the risk of infection. However, we do not know how long these measures will be enforced for, and whether or not subsequent pandemic waves can be expected. It is very likely that people might still fear social contact when social distancing rules are no longer compulsory, affecting activity, participation and travel (De Vos, 2020). In any case COVID-19 prompted cities to create safe spaces for walking and bicycling through the redesign of road infrastructures, the possibility the recuperation of the capacity

One of the strategies adopted in most countries is social distancing. To fulfil this strategy the measures which can be adopted depend on physical dimension of the infrastructure (pathway and lanes), composition and separation of pedestrian flows.

To hold in due account social distancing and guarantee adequate Level of Service, in designing pedestrian pathways, the capacity of infrastructure has a decrease of up to 35 % in standard conditions.

Based on the patterns observed, a set of measures are suggested in order to provide sustainable short-term urban mobility and transport planning interventions in order to plan a smart pedestrian network (e.g., increase infrastructure capacity, flows and queue management, information to users by technology).

The most effective measures adopted by public administrations are to remove motor vehicle lanes from residential streets, extend sidewalks, establish safe cycling routes to and from schools, offices, and close to main roads, create safe access routes on foot and bike, and the implementation of ITS systems designed to develop smart pedestrian networks.

The methodological results given are useful in the scientific framework of walkability. The calculation of required widths should be adopted for the verification of existing infrastructures and the design of pedestrian ways, in accordance to the desired flows and the forecasted pedestrian infrastructure capacity. It would be useful to verify the application of the results in conditions were spacing variables are introduced, as in health and emergency conditions, and stress situations of the system, as evacuation plans.

The policies presented by NACTO in the Table 2 expose a set of different scenarios in function of the infrastructures "dimensions and characteristics", In cases of Covid 19 pandemic, from lockdown to reopening in vaccine and non-vaccine scenarios. And pedestrian infrastructures in the different categories of streets.

Public Health Response	**Neighborhood Streets** (local/residential)	**Neighborhood Main/High Streets** (small retail/office, residential, schools, institutions)	**Major Urban Streets** (transit, retail/offices, institutions, schools)	**Edge Streets & Boulevards** (in/alongside parks, waterfronts, etc.)
Stay-at-home orders in place	• "open streets" (pop-up parks) • slow streets or local access only • speed management (movable barriers, gateway treatments, signs) • Wi-Fi hotspots • open-air cooling zones/sanitation	• sidewalk expansions for queuing, outdoor markets, & access • pop-up bike and roll lanes • temporary pick-up/drop-off delivery zones	• sidewalk expansions for access & queuing • temporary pick-up/drop-off zones • shorten signal cycles • put pedestrian signals on recall	• street closures to vehicular traffic, for medical services, recreation, markets, etc.
Pre-vaccine re-opening	• local-access only treatments • lane removal/ street closures for schools & religious/cultural service providers	• tactical lane/parking space removal, street closures for outdoor restaurant seating, outdoor markets, etc. • sidewalk expansions for queuing & access • tactical bike lanes • designated pick-up/ drop-off delivery zones • bike & shared micromobility parking corrals • lane removal/street closures for schools & religious/cultural service providers	• bus-only lane, tactical islands/in-lane stops, bus priority signals, expanded bus stops • lane removal/parking space removal for outdoor restaurant seating, outdoor markets • sidewalk expansions for queuing & access • protected bike lanes speed management	• street closures to vehicular traffic, e.g. for recreation, markets, schools, etc. • expanded bike lanes & bike/shared micromobility parking zones • speed management
Vaccine/post COVID-19	• speed management (e.g. speed limit changes & geometry) • play streets, slow streets, and local-access-only policies & design	• sidewalk widenings • speed management (e.g. speed limit changes & geometry) • expanded bike lanes & bike/shared micromobility parking zones	• bus-only lanes with offboard fare collection, bus islands, and amenities • high frequency bus service • expanded bike lanes & bike/shared micromobility parking zones • sidewalk widenings • speed management	• open space expansions • expanded bike lanes & bike/shared micromobility parking zones • speed management

Tab.2 Types of Policies to consider (NACTO, 2020)

The results shown in such a research open the road for further investigation aiming to create a more walkable cities/towns which encourage the active mobility. Then, the further development of such a study is addressed to point out the walkability measures. It should involve the review and comparison of walkability measures. Component measures of walkability indices such as density of services and pedestrian infrastructure would be of particular interest. Therefore, the correlation and assessment methods of walkability and urban vitality should be studied, focusing on their theoretical and practical implication for urban design, policy, and decision making.

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