REGION
The Journal of ERSA
Powered by WU

Volume 13, Number 1, 2026, 23–42
DOI: 10.18335/region.v13i1.616

journal homepage: region.ersa.org
ISSN: 2409-5370

Regional Disparities in Italy: Developing a Composite Indicator of Physical Activity, Health, and Mobility

Giorgio Cecchi[1]

[1] Università Telematica degli Studi – IUL, Florence, Italy

Received: 1 July 2025/Accepted: 23 February 2026

Abstract. Quality of Life in urban settings is intricately tied to active transportation, public health, and physical activity, capturing the growing societal emphasis on sustainable mobility and well-being. This study develops a composite indicator to evaluate regional Quality of Life across Italy, utilizing data from the 2021 ISTAT (Italian National Institute of Statistics) survey "Aspects of Daily Life." Employing Principal Component Analysis for weighting, the indicator identifies key dimensions of urban well-being, including active transportation, physical activity, and general health. The results reveal pronounced disparities between central-northern and southern Italy, driven by differences in infrastructure, access to health resources, and socio-economic conditions. Northern regions consistently outperform southern counterparts, where structural challenges hinder improvements in Quality of Life. These findings underscore the urgent need for targeted, equity-focused policies to address regional disparities and enhance urban environments, with a particular focus on improving accessibility and public health in underperforming regions. The study provides valuable insights for policymakers aiming to promote sustainable and inclusive urban development.

Key words: Composite Indicator; Quality of Life; Active Transport; Health; Physical Activity

1 Introduction

Active transportation and general health are critical determinants of Quality of Life (QoL) in urban and regional contexts (Pazhuhan et al. 2020). In Italy, the extent to which citizens engage in active modes of transportation, such as walking and cycling, varies significantly across regions, as does the accessibility of public transport systems (Beria et al. 2017). These factors play a crucial role in shaping mobility patterns (Huan et al. 2023), reducing car dependency (Wiersma 2020), alleviating traffic congestion, and improving air quality (Cheshmehzangi, Thomas 2016). Simultaneously, engaging in regular physical activity, including cycling and walking, has been shown to improve overall health outcomes, reducing the risk of chronic diseases such as cardiovascular conditions and obesity (Miles 2007).

In addition to transportation, QoL is heavily influenced by the health status of the population, which reflects broader socio-economic and environmental factors (Bowling, Windsor 2001). Regions with higher levels of participation in regular sports activities tend to report better health outcomes (Lera-López, Marco 2018) as consistent physical

activity is essential for both physical and mental well-being (Kim et al. 2017). However, regional disparities in access to opportunities for active living, such as infrastructure for cycling and walking or sports facilities, contribute to differences in citizens' health across Italy (Costa et al. 2020).

Traditional indicators of well-being, such as GDP per capita, as well as multidimensional QoL frameworks developed by national and international institutions – including the Human Development Index (Anand, Sen 1994), the OECD Better Life Index, the Italian BES (Benessere Equo e Sostenibile) framework, and the Environmental Performance Index (Wendling et al. 2020) – typically rely on a broad combination of socio-economic, environmental, and subjective dimensions. While these approaches provide comprehensive assessments of societal well-being, many of the included variables are only indirectly related to everyday mobility behaviours and physical activity.

GDP per capita is widely used as a general proxy for well-being (Bechtel 2019) but is deliberately excluded from the present composite indicator. Although GDP is correlated with overall QoL, it also captures expenditures that do not necessarily enhance well-being – such as those related to tobacco consumption or healthcare costs – thereby limiting its suitability for assessing health- and mobility-related dimensions of urban well-being (Balestra et al. 2018, Shrotryia, Singh 2020). Conversely, indices focusing on transportation or environmental performance – such as the EU-framework for Sustainable Urban Mobility Indicators (Finger, Serafimova 2020) primarily assess infrastructural or environmental conditions and seldom incorporate direct measures of population health, such as physical activity levels or self-reported well-being.

This fragmentation leaves a gap for metrics that specifically evaluate how urban mobility patterns and health behaviours jointly shape regional well-being.

The contribution of this study lies precisely in addressing this gap. The index proposed here is innovative because it isolates two strictly interdependent and mutually reinforcing domains – (1) Physical Health and Active Transportation, and (2) Public and Pedestrian Commuting – capturing a specific dimension of urban well-being that is both health-related and environmentally grounded. Unlike existing QoL measures, the proposed indicator deliberately excludes economic and subjective dimensions that may obscure the direct effects of mobility patterns and physical activity on well-being. By prioritising variables that simultaneously promote personal health and environmentally sustainable behaviours, the index provides a concise, policy-relevant, and domain-specific tool particularly suited to regional analysis within the Italian context. Moreover, the indicator allows for a clearer interpretation of cross-regional disparities, which are known to follow a North–South divide in Italy in terms of health, socio-economic conditions, and mobility infrastructures (Leydesdorff 2021).

The first dimension, Physical Health, and Active Transportation examines the percentage of people who cycle to work, the proportion of the population reporting good health, and those who engage in regular sports activities. These variables capture the broader influence of lifestyle choices and regional infrastructure on health outcomes and overall well-being.

The second dimension, Public and Pedestrian Commuting, focuses on the percentage of population using public transport or walking to commute to work. These indicators provide insights into the accessibility and sustainability of transportation systems across regions, highlighting areas that support more active and environmentally friendly commuting practices.

Using data from the Italian National Institute of Statistics, ISTAT (https://www.istat.it), the study constructs a composite indicator to facilitate cross-regional comparisons and track changes over time.

The remainder of the paper is structured as follows. Section 2 reviews the literature on the mobility–health nexus and on QoL measurement, highlighting gaps in existing approaches. Section 3 outlines the theoretical framework and motivates the choice of the two dimensions. Section 4 describes the data and methodology used to construct the composite indicator. Section 5 presents and discusses the empirical results, while Section 6 concludes with policy implications, limitations, and directions for future research.

2 Literature review

2.1 The Mobility–Health Nexus in Regional Studies

Research at the intersection of regional studies, mobility behaviours, and public health has increasingly demonstrated that the spatial organisation of cities and regions plays a decisive role in shaping QoL. A large body of evidence shows that features of the built environment – including walkability, street connectivity, land-use mix, green and recreational spaces, and active mobility infrastructure – significantly influence both physical activity levels and health outcomes (Baobeid et al. 2021, Pontin et al. 2022). Moreover, mobility is not only a matter of physical movement but also a social and relational practice: everyday travel shapes opportunities for interaction, connectedness, and inclusion, influencing how individuals experience urban and regional environments (Te Brömmelstroet et al. 2017). This reinforces the idea that mobility conditions affect well-being through both health-related pathways and broader social mechanisms.

Walkable and transit-oriented environments are associated with higher rates of active commuting (Saelens, Handy 2008), lower incidence of obesity and cardiovascular diseases (Sallis et al. 2012) and improved mental well-being (Nakamura 2022). This literature provides a strong conceptual basis for considering active transportation and health behaviours as key determinants of urban and regional well-being.

The regional mobility literature further demonstrates that accessibility – defined as the ease with which individuals can reach jobs, services, and opportunities – constitutes a core dimension of regional equity and QoL (Geurs, van Wee 2004). High levels of public transport accessibility not only reduce car dependency and emissions but also enhance social inclusion and labour market participation (Papa, Bertolini 2015). Conversely, regions with weak transit systems often face compounded disadvantages, including limited mobility choices, higher exposure to pollution, and reduced participation in social and economic life (Lucas 2012). These mechanisms justify the inclusion of *public and pedestrian commuting* as a structural component of well-being.

At the same time, health outcomes vary significantly across regions due to differences in lifestyles, socio-economic structures, and access to facilities for sports, recreation, and active living (Rey 2025). Regular physical activity, whether achieved through leisure sports or active commuting, is strongly associated with lower morbidity and higher perceived health (Warburton, Bredin 2017). The regional distribution of sports participation, cycling rates, and self-reported health therefore captures critical variations in lifestyle-driven health that are relevant for QoL assessments. Integrating these indicators into the measurement of well-being is consistent with both public health research and the broader agenda of sustainable regional development.

Within regional studies, inequalities in mobility and health intersect with long-standing territorial imbalances shaped by socio-economic structures, governance capacity, and institutional performance (Rodríguez-Pose 2020). The Italian context exemplifies this pattern: the persistent North–South divide manifests not only in income and productivity gaps but also in disparities in transport infrastructure, urban accessibility, and public health indicators (De Muro et al. 2011). Regions in Southern Italy exhibit lower public transport supply, reduced walkability, and more limited opportunities for active living (Asso 2023), all of which contribute to weaker health outcomes and lower regional QoL. These territorial disparities make Italy a pertinent empirical setting for analysing the interaction between mobility, health, and well-being (Ferrara, Nisticò 2015).

While concepts such as territorial cohesion, governance quality, and regional resilience remain central to understanding regional disparities, an excessively broad review risks diluting the argument. What is most relevant for the present study is that resilient and inclusive regions are those that offer equitable access to mobility options and promote healthy behaviours (Medeiros, Rauhut 2020, Simmie, Martin 2010). Improvements in active transportation infrastructure, public transit, and pedestrian environments have been shown to simultaneously strengthen environmental sustainability, social inclusion, and population health – key components of resilient regional development.

2.2 *Quality of Life Measurements*

QoL measurement has become an essential focus in social science and policy due to its comprehensive implications for health, well-being, and societal satisfaction. Traditional unidimensional indicators, such as income or employment rates, have proven inadequate for capturing the complexity of QoL, which involves multidimensional factors including health, social relationships, environment, and individual satisfaction (Maggino 2023). QoL is a critical societal indicator, impacting policies and personal well-being (Verdugo et al. 2005), and has therefore garnered attention from various stakeholders, including governments, researchers, and national and international statistical institutes. Given its complexity, recent efforts have emphasized the use of composite indicators to address the limitations of single metrics. This section examines several prominent projects and composite indices developed to provide a more comprehensive assessment of QoL.

One of the pioneering efforts to measure equitable and sustainable well-being on a national scale is Italy's BES project (https://www.istat.it/statistiche-per-temi/focus/benessere-e-sostenibilita/la-misurazione-del-benessere-bes/gli-indicatori-del-bes/). It was launched in 2013 by ISTAT in collaboration with the National Council for Economics and Labour (CNEL). BES integrates multiple dimensions of QoL, including health, education, environment, economic well-being, and civic engagement, with the goal of assessing well-being at both national and regional levels (De Rosa 2018). By incorporating both objective indicators (such as income and employment) and subjective aspects (such as perceived safety and satisfaction), BES stands out as one of the earliest frameworks to combine objective data with self-reported measures. This innovative approach enables policymakers to address regional disparities, allowing for targeted interventions that consider both economic and social dimensions of well-being. By 2024, BES is composed of 152 indicators organized into 12 domains, covering a broad range of QoL aspects. Although this extensive coverage provides a comprehensive view of well-being, the large number of indicators and domains makes the results complex to interpret and synthesize for policy decisions or comparisons across regions.

At the European level, the EU Statistics on Income and Living Conditions (EU-SILC; https://ec.europa.eu/eurostat/web/microdata/european-union-statistics-on-income-and-living-conditions/) launched in 2004, serves as a pan-European initiative to assess material and social conditions in households across EU member states. While EU-SILC primarily targets income distribution, poverty, and social exclusion, it also provides insights into broader QoL indicators, such as housing quality, health, and education. The initiative's approach represents a shift in European social policy, focusing on social inclusion, housing, and healthcare to enhance living conditions (Engsted 2013). By providing comparable data across countries, EU-SILC enables researchers and policymakers to identify and address disparities across the EU. The data collected through EU-SILC informs policies on social inclusion, housing, and healthcare, demonstrating the program's importance in shaping interventions aimed at improving the QoL across various societal dimensions (Wolff et al. 2010). A limitation of EU-SILC is that it emphasizes household-level indicators and may not fully capture individual subjective experiences or urban-specific aspects of QoL.

On a more focused scale, the Safe Cities Index (https://impact.economist.com/projects/safe-cities/), first developed by the Economist Intelligence Unit in 2015, concentrates on measuring QoL within urban environments, specifically addressing the essential factors of safety and security. This index ranks cities worldwide on a range of parameters, including digital security, health security, infrastructure, and personal safety. Given that safety is an indispensable aspect of QoL, this index provides insights into how cities can enhance residents' QoL by prioritizing security. The Safe Cities Index is particularly useful for comparing urban safety across various socio-economic contexts, illustrating how investments in infrastructure and public safety initiatives can shape both perceived and actual QoL in cities. However, the index's emphasis on safety underscores the need to integrate additional dimensions, such as environmental quality and access to public services, within broader QoL frameworks. While it provides detailed insights on urban safety, it does not integrate broader dimensions like environmental quality, social inclusion, or access to services.

In addition to these targeted initiatives, the Better Life Index by the Organisation for Economic Co-operation and Development (OECD https://www.oecd.org/), introduced in 2011, offers a comprehensive and customizable approach to QoL assessment. This index includes key indicators like housing, income, jobs, education, environment, civic engagement, and work-life balance. A unique feature of the Better Life Index is that it allows individuals to assign weights to each dimension based on their personal priorities, offering valuable insights into how QoL perceptions vary across cultural and individual contexts (Mizobuchi 2014). By allowing for customized prioritization, the index acknowledges the inherent subjectivity of QoL while providing standardized data for cross-country comparability. The index has notably influenced policy decisions in OECD countries, particularly in areas related to housing, employment, and environmental protection, highlighting its impact on shaping well-being policy in diverse socio-economic settings. Despite its flexibility and individual weighting of dimensions, the index depends on self-reported priorities and may be influenced by cultural norms, complicating cross-country comparability.

An innovative and increasingly influential model in urban planning that impacts QoL is the 15-Minute City concept, first proposed in 2016 and popularized by urban planner Carlos Moreno. The 15-Minute City framework promotes urban design principles that ensure residents can access essential services, such as healthcare, education, leisure, and commerce, within a 15-minute walk or bike ride from their homes (Papadopoulos et al. 2023). By reducing dependency on cars and fostering local connectivity, this model directly supports goals related to environmental sustainability, social cohesion, and overall well-being (Moreno 2024). Although not a statistical measure, the concept complements QoL objectives by emphasizing urban mobility, environmental sustainability, and the importance of local access to services. Cities like Paris have embraced the 15-Minute City model, reshaping urban policies to reduce traffic congestion, promote green spaces, and enhance local service accessibility (Allam et al. 2022). While primarily implemented in urban areas, the 15-Minute City could serve as a guiding framework for future QoL measures by illustrating the value of proximity and accessibility. Although it emphasizes accessibility and urban sustainability, it is primarily conceptual and not yet operationalized as a quantitative measure, limiting its direct applicability in large-scale QoL assessments.

Several additional composite indices contribute to the assessment of urban QoL. The Mercer Quality of Living Survey (https://mobilityexchange.mercer.com/quality-of-living-reports), for example, evaluates cities on aspects like political stability, healthcare, education, and environmental quality. Since its inception in 1994, this survey has helped multinational organizations and expatriates evaluate liveability in various cities, influencing economic and labour migration decisions (Okulicz-Kozaryn, Valente 2019). Its main limitation is that it is oriented toward expatriates and multinational organizations, which may not reflect the experiences of the local population. Another relevant indicator, the Global Liveability Index, also developed by the Economist Intelligence Unit, ranks cities based on healthcare, culture, environment, and infrastructure (Giap et al. 2014). It provides useful comparisons but may overlook local social inequalities and subjective well-being factors.

Taken as a whole, these frameworks illustrate the diverse approaches to QoL measurement, recognizing well-being as a multidimensional construct. While each provides valuable insights, they also present limitations, including emphasis on specific domains, unweighted or overly complex sets of indicators, potential overemphasis on economic factors, or reliance on subjective assessments. These considerations highlight the potential value of a well-balanced composite QoL measure based on reliable official statistics, carefully structured to integrate multiple relevant dimensions, providing a clear, interpretable, and comparable assessment of QoL across regions and populations.

3 Theoretical Framework

The development of a composite indicator for assessing QoL requires the selection of dimensions that capture key aspects of well-being while remaining measurable, policy-

relevant, and comparable across contexts (Maggino, Zumbo 2011). In this study, the two selected dimensions – Physical Health and Active Transportation, and Public and Pedestrian Commuting – are grounded in both theoretical and practical considerations and address central mechanisms through which social, environmental, and health-related factors shape regional disparities in QoL. These domains are also closely aligned with areas of public policy intervention aimed at improving citizens' well-being, making them particularly suitable for cross-regional analysis.

Focusing on only two dimensions reflects a deliberate emphasis on simplicity and transparency. The composite indicator is designed to allow a clear and immediate interpretation as a measure of sustainable health-related behaviours and sustainable urban mobility. Limiting the number of dimensions is therefore intended to enhance interpretability and communicability, rather than to provide an exhaustive representation of all QoL domains (Bruzzi et al. 2022).

These two dimensions capture key aspects of daily life that are measurable, policy-relevant, and comparable across regions. They are also areas in which public interventions are particularly prominent, making them especially suitable for cross-regional analysis. Importantly, the indicator adopts an explicitly individual-centred perspective: it focuses on behaviours and conditions experienced directly by individuals, which simultaneously generate broader social and environmental effects. Consequently, the selected indicators refer to the proportion of people engaging in specific practices – such as using public transport, walking or cycling to work, engaging in physical activity, or reporting good health – rather than to system-level characteristics. This choice reflects a conceptual distinction between environment-centric indicators (e.g. pollution levels or transport infrastructure supply) and individual-centric indicators, where sustainability emerges through aggregated individual behaviours.

Similarly, environmental indicators, such as air pollution or emissions, are excluded following the same rationale. Although highly relevant for QoL, their inclusion would shift the focus of the composite indicator towards environmental outcomes rather than individual behaviours, thereby altering its conceptual scope and complicating interpretation. Likewise, transport-related indicators referring to the quantity or quality of available services are not considered, as they describe infrastructural conditions rather than actual mobility practices. By contrast, commuting behaviours – particularly the use of public transport and walking – capture how individuals interact with urban mobility systems in their everyday lives, while also addressing key issues of accessibility, sustainability, and social inclusion (Cottrill et al. 2020).

Finally, relying exclusively on quantitative, non-subjective indicators further supports the clarity and comparability of the composite measure. Subjective indicators, while valuable in QoL research, are more sensitive to cultural norms, individual expectations, and response styles, which may reduce cross-regional comparability (Maggino 2017, Diener et al. 2018). All variables included in the indicator are therefore expressed as percentages of individuals who report a given condition or behaviour, enhancing statistical robustness, facilitating aggregation, and ensuring a more straightforward interpretation of the resulting index. The first dimension, Physical Health, and Active Transportation, underscores the importance of active lifestyles and their direct impact on health outcomes. Regular cycling to work and participation in physical activities are well-known for their positive effects on both mental and physical health, contributing to reduced risks of chronic diseases and healthcare costs. However, significant disparities exist in physical activity levels across Italy. ISTAT data from 2021 reveals that only 23.6% of Italians aged 3 and older engage in regular physical activity, with much higher rates in northern regions like Trentino-Alto Adige (39.8%) and lower rates in southern regions such as Campania (14.3%). The inclusion of cycling in this dimension reflects the importance of regional infrastructure, such as bike lanes, in shaping commuting patterns and promoting active lifestyles. By incorporating both cycling to work and general health indicators (e.g., the percentage of people reporting good health), this dimension offers a holistic view of how lifestyle choices and access to physical activity opportunities shape public health.

The second dimension, Public and Pedestrian Commuting, is critical in assessing how accessible and sustainable mobility is within different regions. Public transport plays a dual role, reducing car dependency and lowering emissions, while also promoting social inclusion by improving access to work and services. Walking to work, similarly, enhances both physical well-being and urban sustainability. According to ISTAT data, in 2021, 10.5% of the Italian population regularly used public transport to commute, with significant regional variation: in regions like Lazio, where Rome is located, usage is much higher (26.0%), whereas in southern regions, reliance on private cars is more common. Walking also represents an active form of commuting, albeit with variation depending on the urban context and available infrastructure. The integration of public transport use and walking into this composite indicator highlights their importance in promoting both environmental sustainability and personal health.

In summary, the two dimensions identified for the composite indicator – commuting via public transport and walking, and physical activity, and general health status – provide a comprehensive framework for evaluating urban QoL across regions. Each dimension reflects essential aspects of daily life that collectively influence both individual well-being and broader societal health. The decision to focus on active transportation and physical health aligns with this principle, as these domains are both measurable and critical determinants of QoL at the regional level (Maggino 2017). By integrating these interconnected areas, the composite indicator offers a nuanced perspective on how factors such as transportation infrastructure, active commuting, and health outcomes interact to shape regional disparities in QoL.

4 Methodology

4.1 Data

The study uses data from the ISTAT "Aspetti della Vita Quotidiana" (Aspects of Daily Life) survey. The sample survey "Aspects of Daily Life" is part of the integrated system of Multipurpose Surveys on families, which was launched in 1993 to gather information on individuals and households. Conducted annually, the survey provides insights into the daily habits of citizens and the challenges they encounter. The survey, based on a sample, is conducted annually, typically in March. It involves approximately 20,000 households and 50,000 individuals. Since 2018, the survey has been administered using a mixed technique of sequential CAWI (Computer Assisted Web Interview)/PAPI (Paper And Pencil Interview) data collection. The survey design generally involves proposing a web interview to all sample families first, and subsequently sending an interviewer to non-responding families.

For the 2021 survey, the sample was integrated with the sampling design used for the Master Sample of the Permanent Population Census[1]. Specifically, the sample municipalities for this survey were selected as a sub-sample from the 2,850 municipalities of the Master Sample used in 2018. To this end, the classic sampling scheme for family surveys was applied to the sub-universe of municipalities surveyed during the Permanent Census in October 2018. Within each area, defined by the intersection of regions and six types of municipalities, the municipalities were divided into two subsets: the larger municipalities were classified as Self-Representative (AR), while the remaining ones were classified as Non-Self-Representative (NAR). NAR municipalities were further divided into strata of equal size based on population, and two sample municipalities from each stratum were selected with probabilities proportional to their size. For each municipality (both AR and NAR), a cluster sampling method was used: clusters (families) were randomly selected from the population registry, and all members of each selected family were surveyed. The minimum number of sample families per municipality was set at 24.

[1]The Permanent Population Census in Italy is based on a combination of sample surveys and statistically processed administrative data. It is conducted annually and is part of the Integrated System of Statistical Registers managed by the Italian National Institute of Statistics (ISTAT). This system was established in 2012 (art. 3 of d.lgs 179/2012, converted with modifications into law 221/2012). The strategy of permanent censuses is extended to all thematic areas, including agriculture, starting from 2021.

Families were chosen from the theoretical sample selected for the Master Sample, and for each family included, data were collected on all household members.

Within this framework, it is important to note that the age ranges used in the indicators are determined by the design of the ISTAT survey and cannot be modified. For instance, the commuting indicator ("percentage of individuals aged 15 and older who commute to work by foot, public transport, or bicycle") and the physical activity indicator ("percentage of individuals aged 3 and older who engage in regular physical activity") follow the age specifications provided by ISTAT in the publicly available datasets. While these ranges include children or younger adolescents who may participate in physical activity as part of mandatory school programs, the composite indicator is intended to capture the prevalence of behaviours associated with health and sustainable mobility, regardless of the voluntariness or motivation behind them. Similarly, in the case of commuting, individuals may use public transport or walk out of necessity rather than preference, yet these behaviours remain relevant for assessing sustainable mobility. These constraints reflect the design of the survey rather than arbitrary choices by the authors and are explicitly acknowledged as a limitation of the study.

The distributions of the simple indicators used in the study are reported in Table 1. The table shows notable differences in commuting patterns, health status, and physical activity across regions, metropolitan zones, and municipality sizes. Walking and cycling rates are generally higher in smaller municipalities and central metropolitan areas, while public transport use is concentrated in central metropolitan areas. Northern regions tend to have higher rates of cycling and better reported health, whereas southern regions show lower cycling rates and slightly lower health and physical activity levels.

4.2 Analytical Approach

To construct the composite, an approach based on PCA is adopted to determine the weights of the variables within the index. This methodology is particularly suitable for multidimensional constructs, as it allows for the consideration of intercorrelations among variables while reducing the dimensionality of the data (Jolliffe 2002, Mazziotta, Pareto 2019). Unlike more subjective weighting methods, PCA provides an objective, data-driven procedure for assigning weights based on each variable's contribution to the overall variance in the dataset (Abdi, Williams 2010). This choice aligns with tha argument of Maggino (2017) that multidimensionality must be effectively captured in composite indicators to reflect the complexity of phenomena like QoL.

As shown in Table 1, the individual indicators all display relatively small ranges. To address this issue and ensure that each indicator had an appropriate influence on the composite index, the rescaling technique in (1) was applied.

$$I_{ic} = \frac{x_{ic} - (\min(x_i) - 0.05)}{\max(x_i) - (\min(x_i) - 0.05)} \tag{1}$$

Where

I_{ic} is the value of indicator i after the transformation for case c, and
x_{ic} is the value of indicator i before the transformation for case c.

A 0.05 adjustment was introduced to ensure that minimum values do not become zero during the rescaling process, as this would prevent the use of the geometric mean in the aggregation of the elementary indices.

This normalization process increased the effect of indicators with limited variability by expanding their range, thus ensuring that even those with small initial dispersion contribute meaningfully to the composite score. The same rescaling technique was also applied to the final composite indicator, solely to expand its range and ensure better differentiation between regions, while maintaining the original rankings unchanged (Maggino 2006).

In this context, the aggregation of the indicators and dimensions in the composite indicator was performed using a weighted geometric mean. This method was chosen because it reduces compensability, ensuring that poor performance in some indicators

Table 1: Distribution of simple indicators by Italian regions, metropolitan area zones, and municipality size, year 2021

Region	Percentage of individuals aged 15 and older who commute to work on foot	Percentage of individuals aged 15 and older who commute to work using public transportation	Percentage of individuals aged 15 and older who commute to work by bicycle	Percentage of individuals aged 15 and older in good health	Percentage of individuals aged 3 and older who engage in regular physical activity
Piemonte	15.1	9.3	2.6	70.3	26.0
Valle d'Aosta	20.4	7.7	2.3	74.3	32.5
Liguria	15.8	16.5	1.3	71.0	23.1
Lombardia	12.1	16.1	4.8	71.9	28.0
Trentino-Alto Adige	14.2	10.1	9.4	79.6	39.8
Veneto	7.3	5.7	6.7	70.6	27.8
Friuli-Venezia Giulia	8.2	4.8	5.2	70.3	24.2
Emilia-Romagna	10.7	6.1	5.4	70.9	28.0
Toscana	9.8	6.0	3.3	72.3	26.5
Umbria	10.9	4.8	1.4	70.2	23.7
Marche	9.4	2.2	2.7	69.3	25.5
Lazio	11.5	26.0	0.9	72.4	25.8
Abruzzo	13.8	5.5	1.9	70.5	23.5
Molise	13.7	8.8	0.6	67.3	15.4
Campania	17.2	10.7	1.4	73.3	14.3
Puglia	17.0	5.4	1.1	70.3	17.9
Basilicata	15.5	6.2	0.3	65.8	16.0
Calabria	14.0	7.8	0.5	64.0	15.8
Sicilia	11.6	5.1	1.9	70.7	15.6
Sardegna	13.1	4.0	2.3	66.5	22.3
Metropolitan Area (MA) zone					
Central MA	15.9	29.0	4.3	70.7	25.3
Peripheral MA	9.3	14.4	2.2	72.1	24.7
Municipality size					
$\leq$ 2.000 in.	12.6	3.0	0.8	67.7	20.3
2.001 - 10.000 in.	10.6	5.0	2.8	70.2	22.2
10.001 - 50.000 in.	12.3	6.4	3.2	72.1	24.0
>50.000 in.	14.0	7.7	5.2	71.2	23.4

Source: ISTAT Survey "Aspetti Della Vita Quotidiana", year 2021 (https://www.istat.it/microdati/-multiscopo-sulle-famiglie-aspetti-della-vita-quotidiana/)
Notes: According to the ISTAT statistical classification, central municipalities of metropolitan areas are the main municipalities of Italy's largest metropolitan areas (Turin, Milan, Venice, Genoa, Bologna, Florence, Rome, Naples, Bari, Palermo, Catania, and Cagliari). Peripheral municipalities of metropolitan areas are the satellite municipalities surrounding the central municipality of a metropolitan area, defined based on functional relationships such as commuting flows and socio-economic links within the metropolitan area.
The indicator "Percentage of individuals aged 15 and older who commute to work using public transportation" is obtained as the sum of the following indicators: Percentage of individuals aged 15 and older who commute to work using I. Train II. Tram, Bus III. Metro IV Pullman

cannot be fully offset by high performance in others, as would occur with an arithmetic mean. This approach is particularly effective when dealing with percentages, as it emphasizes balanced improvements across all dimensions, penalizing those regions with extreme variability in performance (El Gibari et al. 2019). By leveraging the geometric mean, the composite indicator better captures the interdependencies among dimensions, such as active transportation and physical health, and ensures that the most vulnerable areas are not masked by stronger performances in other areas.

The aggregation process involves two main steps:

1. *Aggregation of indicators within each dimension*: For each dimension, the indicators are aggregated using a weighted geometric mean, where the contribution of each indicator is determined by its respective weight. The formula is as follows:

$$D_j = \prod_{i=1}^{n_j} x_i^{w_{ij}} \tag{2}$$

Where

D_j is the value of the dimension j
x_i is the value of indicator i within dimension j
w_{ij} is the standardized weight of indicator i in dimension j
n_j is the number of indicators in dimension j

2. *Aggregation of dimensions*: Once the indicators are aggregated within each dimension, the dimensions themselves are aggregated using another weighted geometric mean, with weights assigned to each dimension based on their relative importance. The formula is:

$$CI = \prod_{j=1}^{m} D_j^{w_j} \tag{3}$$

Where

D_j is the aggregated value of the dimension j
w_j is the standardized weight of dimension j
m is the number of dimensions

The decision to utilize PCA as the primary method for weight selection is supported by existing literature on the development of composite indices for complex phenomena, such as QoL and socio-economic development (Nardo et al. 2005). In this context, PCA not only minimizes the risk of collinearity among variables but also ensures that the composite index reflects the multidimensional nature of the phenomenon under investigation.

In terms of aggregation, the PCA-derived weights are used to compute a weighted sum of the selected indicators for each region, resulting in a composite score that reflects QoL in terms of active transportation and physical health. The analysis was conducted using IBM SPSS Statistics version 26.0 (https://www.ibm.com/it-it/spss).

Table 2 presents the standardized weights assigned to each indicator and dimension in the construction of the composite indicator, which follows a hierarchical model. This model is structured in two levels: the first level consists of the primary dimensions, while the second level includes the specific indicators within each dimension. This hierarchical approach reflects the multidimensional nature of the phenomenon being measured.

The standardized weights for each variable, derived from PCA loadings, reflect their contribution to the composite index, while dimension weights correspond to the percentage of variance explained by each component, ensuring balanced emphasis on both transportation and health outcomes. This approach highlights regional strengths and deficits, with higher composite scores for regions performing well across dimensions and lower scores where active transportation and health outcomes are limited, guiding policy priorities.

Table 2: Standardized weights assigned to variables and dimensions based on principal component analysis

Dimension	Indicator	Standardized weight of the indicator	Standardized weight of the dimension
Physical Health, and Active Transportation	Percentage of individuals aged 15 and older who commute to work by bicycle	0.324	0.640
	Percentage of individuals aged 15 and older in good health	0.322	
	Percentage of individuals aged 3 and older who engage in regular physical activity	0.354	
Public and Pedestrian Commuting	Percentage of individuals aged 15 and older who commute to work on foot	0.526	0.360
	Percentage of individuals aged 15 and older who commute to work using public transportation	0.474	

The PCA revealed that walking to work and using public transport load on the same component, whereas cycling to work loads with indicators of general health and regular physical activity. This grouping is entirely data-driven, reflecting correlations between the indicators, while the dimension names (Physical Health and Active Transportation and Public and Pedestrian Commuting) were chosen by the author to convey their conceptual meaning. These results suggest that walking to work is more strongly shaped by spatial proximity and urban structure, whereas cycling is more closely associated with additional physical activity. This empirical grouping is also consistent with the literature showing that cycling is more strongly associated with intentional physical activity and lifestyle choices, whereas walking to work often reflects spatial proximity and urban structure rather than health-oriented behaviour (Sallis et al. 2004). Figure 1 illustrates the rotated component space and the relationships between individual indicators and the two dimensions.

A key reason for employing PCA is to ensure that the indicator captures the multidimensionality of QoL (Maggino 2015). By leveraging the eigenvalue criteria (typically retaining components with eigenvalues > 1), PCA allows for the identification of the latent structure of the dataset and focuses on the dimensions that account for the most variance. This step ensures that the final composite indicator robustly reflects the core dimensions of active transportation and health.

After confirming the comparability of the variables, the weights derived from the PCA loadings are applied. These loadings are proportional to the degree of variance that each variable contributes to the principal components, ensuring that the most influential indicators have a greater impact on the final composite score. The weighted variables are aggregated using a linear additive model, resulting in a composite score for each region.

The technical specification applied during the PCA process is the Kaiser-normalized varimax rotation, which enhances the interpretability of the principal components by maximizing the variance of the squared loadings across components (Kaiser 1958) Kaiser–Meyer–Olkin -KMO- Test $= 0.558$ indicating a moderate level of adequacy for conducting factor analysis, and Bartlett's Test: $\chi^2 = 39.1475$; df $=10$; P-value < 0.001 strongly rejecting the null hypothesis of variable independence. This step ensures that each variable

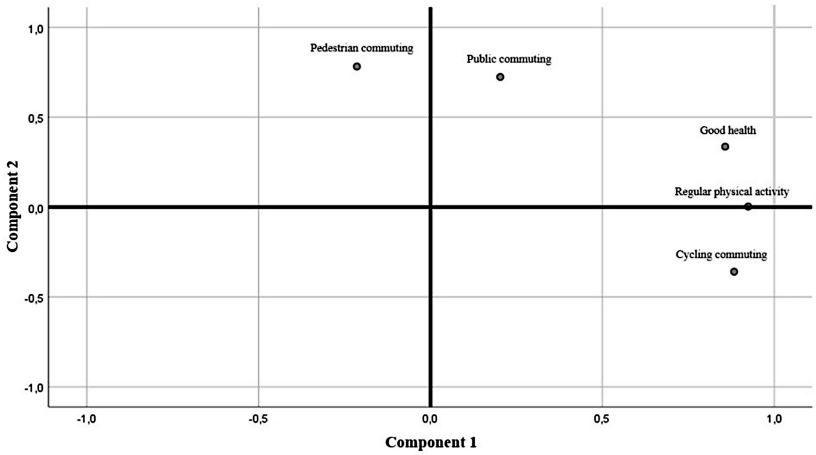

Figure 1: Graph of the rotated components

loads highly on one component, facilitating the interpretation of each dimension's contribution to the overall index. It also mitigates the issue of cross-loadings that could obscure the true influence of individual variables.

Sensitivity and robustness checks are crucial to this study to ensure the stability and reliability of the composite indicator (Greco et al. 2019). A total of 1000 Monte Carlo simulations were conducted using R version 4.1.2 (https://www.r-project.org/), randomly assigning weights from a Uniform distribution (0,1). A mean Pearson's correlation coefficient of 0.90 was calculated, which is considered good for assessing the robustness of the composite indicator. These simulations allowed for the evaluation of how small changes in methodological choices could impact the final rankings of the regions (Nardo et al. 2005).

In conclusion, the internal consistency of the composite indicator is supported by a Cronbach's alpha of 0.782 for the first dimension (Physical Health and Active Transportation), indicating that the variables within this dimension effectively measure a coherent underlying construct (Tavakol, Dennick 2011). The second dimension (Public and Pedestrian Commuting) has a lower alpha of 0.255; however, this is not a concern, as the component captures two complementary aspects of urban mobility – walking and public transport – that reflect distinct but equally relevant behaviours for assessing sustainable commuting patterns. Overall, the use of PCA for determining variable weights and the aggregation method provides a rigorous, statistically grounded framework for assessing regional QoL in Italy. This approach ensures that the composite indicator captures the multidimensional nature of the phenomenon while enabling a nuanced interpretation of the factors contributing to regional disparities, offering meaningful insights for policy and practice.

5 Results

In Table 3, the values are reported in ascending order by region, metropolitan area zone and Municipality size for individual dimensions, and for the composite indicator.

Table 3 reveals pronounced territorial disparities across Italian regions, metropolitan zones and municipality size, confirming a persistent North–Centre versus South divide. This pattern emerges consistently across both dimensions – Physical Health and Active Transportation and Public and Pedestrian Commuting – and is further reinforced in the Composite Indicator.

At the regional level, Southern regions (Calabria, Basilicata, Campania, Molise, Sicily and Puglia) systematically occupy the lower positions in the Composite Indicator ranking. This result is consistent with evidence from the Italian BES framework, according to which the share of individuals reporting good or very good health is, on average, around 10–15 percentage points higher in Northern regions compared to Southern ones.

Table 3: Values sorted in ascending order by region, metropolitan area zone and Municipality size of the two Dimensions and of the Composite Indicator

Region	Physical Health and Active Transportation	Region	Public and Pedestrian Commuting	Region	Composite Indicator
Calabria	0.08	Marche	0.07	Calabria	0.07
Basilicata	0.12	Veneto	0.08	Basilicata	0.11
Campania	0.14	Friuli-Venezia Giulia	0.34	Campania	0.15
Molise	0.18	Toscana	0.52	Marche	0.17
Sicilia	0.30	Umbria	0.52	Molise	0.17
Puglia	0.33	Sardegna	0.55	Veneto	0.23
Sardegna	0.39	Sicilia	0.57	Sicilia	0.23
Lazio	0.43	Emilia-Romagna	0.57	Sardegna	0.29
Liguria	0.43	Abruzzo	0.66	Puglia	0.30
Umbria	0.43	Puglia	0.73	Umbria	0.31
Abruzzo	0.47	Basilicata	0.74	Friuli-Venezia Giulia	0.33
Marche	0.51	Calabria	0.76	Abruzzo	0.39
Piemonte	0.53	Molise	0.78	Toscana	0.43
Friuli-Venezia Giulia	0.59	Trentino-Alto Adige	0.83	Lazio	0.47
Toscana	0.59	Piemonte	0.83	Liguria	0.49
Valle d'Aosta	0.62	Lombardia	0.86	Emilia-Romagna	0.51
Emilia-Romagna	0.65	Valle d'Aosta	0.90	Piemonte	0.53
Lombardia	0.65	Campania	0.92	Valle d'Aosta	0.66
Veneto	0.68	Lazio	0.94	Lombardia	0.67
Trentino-Alto Adige	1.00	Liguria	1.00	Trentino-Alto Adige	1.00
		Metropolitan Area (MA) zone			
Peripheral MA	0.17	Peripheral MA	0.06	Peripheral MA	0.10
Central MA	1.00	Central MA	1.00	Central MA	1.00
		Municipality size			
$\leq$ 2.000 in.	0.06	2.001 - 10.000 in.	0.32	$\leq$ 2.000 in.	0.05
2.001 - 10.000 in.	0.71	$\leq$ 2.000 in.	0.35	2.001 - 10.000 in.	0.30
10.001 - 50.000 in.	0.96	10.001 - 50.000 in.	0.81	10.001 - 50.000 in.	0.81
>50.000 in.	1.00	>50.000 in.	1.00	>50.000 in.	1.00

Similarly, BES indicators on physical activity show that regular participation in sport or physical exercise involves more than half of the population in several Northern and Central regions, while remaining well below 40% in most Southern regions. These gaps are coherently reflected in the lower values of the Physical Health and Active Transportation dimension observed for Southern Italy, where unfavourable socio-economic conditions and less supportive built environments tend to limit active lifestyles (Pirani, Salvini 2012, Costa et al. 2020).

The Public and Pedestrian Commuting dimension further mirrors well-documented regional disparities in transport infrastructure and service provision. BES data on mobility indicate that the availability and use of public transport are substantially higher in Northern regions, where satisfaction with local public transport services exceeds 60% in several cases, compared to values often below 40% in Southern regions (ISTAT 2022). These differences translate into lower effective commuting costs and higher labour market accessibility in the North and Centre, fostering greater reliance on public and pedestrian modes (Vendemmia, Beria 2023, Babapour et al. 2025). The high scores recorded by regions such as Trentino-Alto Adige, Lombardy and Emilia-Romagna in this dimension are therefore fully consistent with BES evidence on transport efficiency and service quality.

Disparities are even more pronounced when considering metropolitan area zones. Central metropolitan areas reach the maximum score across all dimensions, while peripheral metropolitan areas record substantially lower values. In many large cities, such as Rome, reliance on public transport is often driven by the inefficiency of alternatives; private ve-

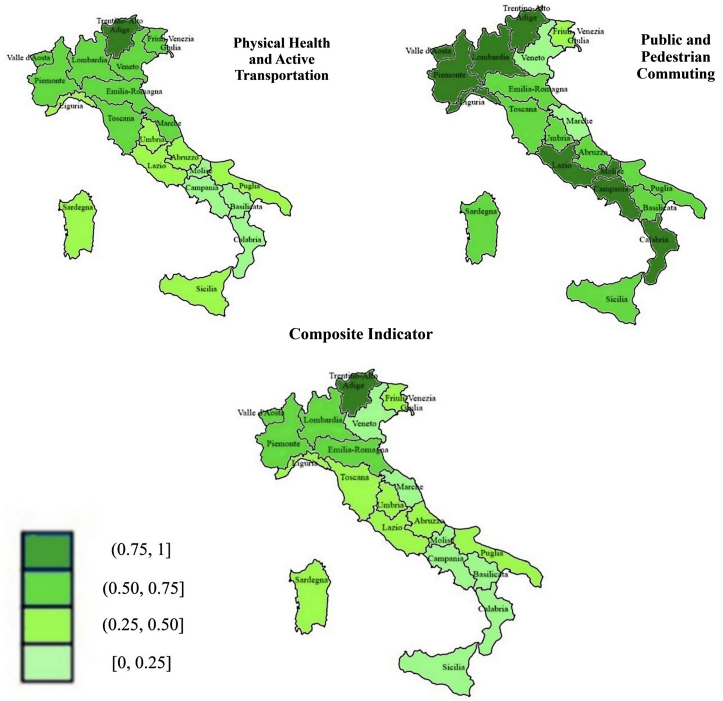

Figure 2: Geographical distribution of the values by region for the two Dimensions and the Composite Indicator

hicle use is often less viable due to congestion and parking challenges (Piccioni et al. 2019, Corazza, Carassiti 2021). This insight underscores that, while public transport is vital for sustainable mobility, its effectiveness and accessibility remain inconsistent across regions. This finding closely aligns with BES indicators on Accessibility to Services, which show that residents of central urban areas enjoy markedly shorter travel times to essential services and higher public transport availability compared to metropolitan peripheries (ISTAT 2022). Urban economics literature has long emphasised how density, mixed land use and functional integration in central areas reduce commuting costs and promote both active mobility and healthier lifestyles (Mariotti et al. 2021).

A similar gradient emerges across municipality size. Very small municipalities ($\leq$ 2,000 inhabitants) consistently score lowest on the Composite Indicator, while municipalities with more than 50,000 inhabitants achieve the highest values. BES data confirm that satisfaction with transport services and accessibility increases monotonically with municipality size, with gaps exceeding 20 percentage points between small rural municipalities and large urban centres (ISTAT 2022). While small municipalities may benefit from lower environmental stress, the scarcity of public transport and limited walkable infrastructure significantly constrain both sustainable commuting and daily physical activity (Giuffrida et al. 2021).

Figure 2 presents maps illustrating the two dimensions alongside the composite indicator, providing a visual understanding of the geographical distribution of values across Italian regions. This mapping enables a clearer analysis of regional patterns and disparities, offering insights into spatial variations in health and transportation metrics and emphasizing areas where interventions might enhance QoL outcomes.

The maps accentuate the regional contrasts between central-northern and southern Italian regions in both individual dimensions and the composite indicator. Veneto stands out as an exception: despite its overall central-northern location, it scores relatively low in the composite indicator due to a particularly low value in the Public and Pedestrian Transportation dimension. In contrast, while some southern regions, such as Molise, Campania, and Calabria, exhibit high scores in the Public and Pedestrian Transportation dimension, their composite indicator values remain lower. This is primarily because they score less favourably in the Physical Health and Active Transportation dimension, and

the use of a geometric mean for aggregation results in limited compensation from higher values in one dimension when paired with lower scores in the other.

6 Conclusions

This study set out to develop and test a composite indicator capturing a specific, policy-relevant dimension of regional well-being in Italy, centred on the interaction between physical health, active lifestyles and sustainable mobility. The empirical results confirm pronounced territorial disparities, closely aligned with the long-standing North–Centre versus South divide, but the main contribution of the paper lies not merely in documenting these differences. Rather, it lies in demonstrating how health-related behaviours and everyday mobility practices jointly structure a distinct dimension of regional inequality that is only partially visible in existing multidimensional frameworks.

A first contribution of the study concerns conceptual clarification. While many QoL indices aim at broad coverage by combining economic, social, environmental, and subjective dimensions, the indicator proposed here deliberately adopts a narrower scope. The results show that even when attention is restricted to only two dimensions – Physical Health and Active Transportation, and Public and Pedestrian Commuting – substantial and systematic territorial gradients emerge. This suggests that health-related mobility behaviours constitute a core mechanism through which regional inequalities are reproduced. For this reason, the indicator should not be interpreted as a comprehensive measure of QoL. A more accurate interpretation is that of an Index of Health and Mobility, capturing a specific but structurally important component of regional well-being.

This positioning responds directly to the risk of conceptual overreach identified by the reviewers. Rather than competing with comprehensive frameworks such as the BES, the OECD Better Life Index or other multidimensional QoL measures, the proposed index should be understood as complementary to them. Its value lies precisely in isolating a behavioural and practice-based dimension – how people move and how this movement relates to health – that is often diluted within broader composite indicators. The strong empirical convergence with BES outcomes in the domains of health, environment and services supports the external validity of the index, while observed divergences across regions (e.g. intermediate performances of Lazio or Sardinia) highlight the additional interpretative leverage gained by focusing explicitly on health–mobility interactions.

A second contribution concerns policy interpretability. Unlike many regional statistics that separately report health outcomes, transport supply or infrastructure endowments, the proposed indicator integrates individual behaviours into a single framework. This allows policymakers to distinguish between different underlying configurations of disadvantage. For instance, low composite scores may result from weak transport accessibility, low engagement in physical activity, or both. Conversely, some regions display relatively good performance in one dimension but not in the other, revealing limited compensability between health and mobility outcomes. This feature is reinforced using a geometric mean, which prevents high performance in one domain from masking structural deficits in the other.

From a policy perspective, this has direct implications. Regions with low scores in both dimensions require integrated interventions – combining investments in public transport, walkability and cycling infrastructure with health promotion policies aimed at increasing physical activity. Regions where transport-related scores are relatively high but health-related scores lag behind may instead benefit more from targeted public health initiatives, sports infrastructure and programmes encouraging active lifestyles. In this sense, the indicator provides actionable insight beyond existing regional statistics, helping to prioritise policy levers rather than merely ranking territories.

The results for metropolitan areas and municipality size further strengthen this interpretation. The sharp contrast between central and peripheral metropolitan areas underscores the role of accessibility, density, and functional integration in shaping both commuting patterns and health behaviours. Similarly, the monotonic increase in scores with municipality size suggests that small municipalities face structural barriers not only in transport provision but also in opportunities for active living. These findings sug-

gest that place-based policies should be differentiated not only by region but also by settlement structure, reinforcing the relevance of the index for multi-level governance.

At the same time, the study has clear limitations that must be acknowledged. The restricted number of dimensions, while enhancing interpretability, necessarily excludes other important aspects of well-being, such as income, housing conditions, environmental quality and subjective life satisfaction. Moreover, the indicator relies on cross-sectional data and on behaviours that may be shaped by necessity rather than choice, particularly in peripheral or disadvantaged areas. These limitations do not undermine the validity of the index but define its scope: it is not intended as a synthetic measure of overall QoL, but as a focused analytical tool addressing the health–mobility nexus.

Future research could build on this framework in several ways. One direction would be to integrate the Index of Health and Mobility into broader dashboards alongside BES indicators, explicitly analysing complementarities and trade-offs. Another would be to extend the analysis over time, assessing whether improvements in transport accessibility or active mobility infrastructure translate into measurable gains in health-related behaviours. Finally, comparative applications to other national contexts could test the generalisability of the approach and its relevance for European cohesion policy.

In conclusion, this study contributes to regional well-being research by proposing a theoretically grounded, empirically robust, and policy-oriented indicator that captures a specific but critical dimension of regional inequality. By focusing on health-related mobility behaviours, the Index of Health and Mobility offers a clear and actionable lens through which policymakers can interpret territorial disparities and design targeted, place-sensitive interventions, without claiming to replace more comprehensive QoL measures.

References

Abdi H, Williams LJ (2010) Principal component analysis. *Wiley interdisciplinary reviews: computational statistics* 2: 433–459. CrossRef

Allam Z, Bibri SE, Chabaud D, Moreno C (2022) The '15-minute city' concept can shape a net-zero urban future. *Humanities and Social Sciences Communications* 9: 1–5. CrossRef

Anand S, Sen AK (1994) Human development index: Methodology and measurement. 5: 1433–1434. New York: Human Development Report Office Occasional Paper 12

Asso PF (2023) New perspectives on old inequalities: Italy's north–south divide. In: della Porta D, Keating M, Pianta M (eds), *Inequalities, Territorial Politics, Nationalism*. Routledge, 22–40

Babapour M, Corazza MV, Gentile G (2025) Urban commuting preferences in Italy: Employees' perceptions of public transport and willingness to adopt active transport based on k-modes cluster analysis. *Sustainability* 17: 5149. CrossRef

Balestra C, Boarini R, Ruiz N (2018) Going beyond GDP: Empirical findings. In: *Handbook of research on economic and social well-being*. Edward Elgar Publishing, 52–103. CrossRef

Baobeid A, Koç M, Al-Ghamdi SG (2021) Walkability and its relationships with health, sustainability, and livability: Elements of physical environment and evaluation frameworks. *Frontiers in built environment* 7: 721218. CrossRef

Bechtel G (2019) GDP is well-being! Results in the USA and China. *Open Journal of Social Sciences* 7: 189–204. CrossRef

Beria P, Debernardi A, Ferrara E (2017) Measuring the long-distance accessibility of Italian cities. *Journal of Transport Geography* 62: 66–79. CrossRef

Bircu C, Cavallaro F, Pozzer G, Nocera S (2024) Exploring the prospects and challenges of sustainable urban mobility: Potential and limits of cycling in Venice. *Journal of Transport and Land Use* 17: 401–422. CrossRef

Bowling A, Windsor J (2001) Towards the good life: A population survey of dimensions of QoL. *Journal of Happiness Studies* 2: 55–82. CrossRef

Bruzzi S, Ivaldi E, Santagata M (2022) Measuring regional performance in the Italian NHS: Are disparities decreasing? *Social Indicators Research* 159: 1057–1084. CrossRef

Cheshmehzangi A, Thomas SM (2016) Prioritizing accessible transit systems for sustainable urban development: Understanding and evaluating the parameters of a transportation system in Mumbai. *Journal of Urban Planning and Development* 142: 4. CrossRef

Corazza MV, Carassiti G (2021) Investigating maturity requirements to operate mobility as a service: The Rome case. *Sustainability* 13: 15. CrossRef

Costa G, Caiazzo A, Marinacci C, Spadea T (2020) Individual and contextual determinants of inequalities in health: The Italian case. In: *The political and social contexts of health*. Routledge, 115–146. CrossRef

Cottrill CD, Brooke S, Mulley C, Nelson JD, Wright S (2020) Can multi-modal integration provide enhanced public transport service provision to address the needs of vulnerable populations? *Research in Transportation Economics* 83: 100954. CrossRef

De Muro P, Monni S, Tridico P (2011) Knowledge-based economy and social exclusion: Shadow and light in the Roman socio-economic model. *International Journal of Urban and Regional Research* 35: 1212–1238. CrossRef

De Rosa D (2018) Capability approach and multidimensional well-being: The Italian case of BES. *Social Indicators Research* 140: 125–155. CrossRef

Diener E, Oishi S, Tay L (2018) Advances in subjective well-being research. *Nature Human Behaviour* 2: 253–260. CrossRef

El Gibari S, Gómez T, Ruiz F (2019) Building composite indicators using multicriteria methods: A review. *Journal of Business Economics* 89: 1–24. CrossRef

Engsted IM (2013) The European context: Measuring social inclusion in the European Union. In: Ruggeri Laderchi C, Savastano S (eds), *Poverty and exclusion in the Western Balkans: New directions in measurement and policy*. 13–27. CrossRef

Ferrara AR, Nisticò R (2015) Regional well-being indicators and dispersion from a multidimensional perspective: Evidence from Italy. *The Annals of Regional Science* 55: 373–420. CrossRef

Finger M, Serafimova T (2020) Towards a common European framework for sustainable urban mobility indicators

Geurs KT, van Wee B (2004) Accessibility evaluation of land-use and transport strategies: Review and research directions. *Journal of Transport geography* 12: 127–140. CrossRef

Giap TK, Thye WW, Aw G (2014) A new approach to measuring the liveability of cities: The Global Liveable Cities Index. *World Review of Science, Technology and Sustainable Development* 11: 176–196. CrossRef

Giuffrida N, Le Pira M, Inturri G, Ignaccolo M (2021) Addressing the public transport ridership/coverage dilemma in small cities: A spatial approach. *Case studies on transport policy* 9: 12–21. CrossRef

Greco S, Ishizaka A, Tasiou M, Torrisi G (2019) On the methodological framework of composite indices: A review of the issues of weighting, aggregation, and robustness. *Social indicators research* 141: 61–94. CrossRef

Huan N, Yao E, Xiao Y (2023) Roles of accessibility and air-rail intermodality in shaping mobility patterns in mega-city regions: Behavioural insights from China. *Cities* 143: 104591. CrossRef

ISTAT (2021) Aspetti della vita quotidiana 2021. https://www.istat.it/microdati/multiscopo-sulle-famiglie-aspetti-della-vita-quotidiana/

ISTAT (2022) *Benessere equo e sostenibile (BES): Rapporto annuale*. Istituto Nazionale di Statistica. https://www.istat.it/tag/rapporto-bes/

Jolliffe IT (2002) Principal component analysis for special types of data. In: Jolliffe IT (ed), *Principal Component Analysis*. Springer, New York, 338–372. CrossRef

Kaiser HF (1958) The varimax criterion for analytic rotation in factor analysis. *Psychometrika* 23: 187–200. CrossRef

Kim ES, Kubzansky LD, Soo J, Boehm JK (2017) Maintaining healthy behavior: A prospective study of psychological well-being and physical activity. *Annals of Behavioral Medicine* 51: 337–347. CrossRef

Lera-López F, Marco R (2018) Sports participation, physical activity, and health in the European regions. *Journal of sports sciences* 36: 1784–1791. CrossRef

Leydesdorff L (2021) Regions, innovations, and the north–south divide in Italy. In: Leydesdorff L (ed), *The Evolutionary Dynamics of Discursive Knowledge*. Springer, Cham, 115–134. CrossRef

Lucas K (2012) Transport and social exclusion: Where are we now? *Transport policy* 20: 105–113. CrossRef

Maggino F (2006) *Gli indicatori statistici: concetti, metodi e applicazioni*. Firenze University Press, Archivio E-Prints

Maggino F (2015) Assessing the subjective wellbeing of nations. In: Glatzer W, Camfield L, Møller V, Rojas M (eds), *Global handbook of QoL*. Springer, Dordrecht, 803–822. CrossRef

Maggino F (2017) Developing indicators and managing the complexity. In: Maggino F (ed), *Complexity in society*. Springer, Cham, 87–114. CrossRef

Maggino F (2023) *Encyclopedia of quality of life and well-being research*. Springer International Publishing, Cham. CrossRef

Maggino F, Zumbo BD (2011) Measuring the Quality of Life and the construction of social indicators. In: Land KC, Michalos AC, Sirgy MJ (eds), *Handbook of social indicators and Quality of Life research*. Springer, Dordrecht, 201–238. CrossRef

Mariotti I, Burlando C, Landi S (2021) Is local public transport unsuitable for elderly? exploring the cases of two italian cities. *Research in Transportation Business & Management* 40: 100643. CrossRef

Mazziotta M, Pareto A (2019) Use and misuse of PCA for measuring well-being. *Social Indicators Research* 142: 451–476. CrossRef

Medeiros E, Rauhut R (2020) Territorial cohesion cities: A policy recipe for achieving territorial cohesion? *Regional Studies* 54: 120–128. CrossRef

Miles L (2007) Physical activity and health. *Nutrition bulletin* 32: 314–363. CrossRef

Mizobuchi H (2014) Measuring world better life frontier: A composite indicator for OECD better life index. *Social Indicators Research* 118: 987–1007. CrossRef

Moreno C (2024) "the 15-minute city": Redesigning urban life with proximity to services. *Barcelona Societat; Journal on Social Knowledge and Analysis* 30

Nakamura K (2022) The relationship between walkability and QOL outcomes in residential evaluation. *Cities* 131: 104008. CrossRef

Nardo M, Saisana M, Saltelli A, Tarantola S, Hoffman S, Giovannini E (2005) Handbook on constructing composite indicators: Methodology and user guide. OECD statistics working papers, no. 2005/03, OECD publishing, Paris. CrossRef

Okulicz-Kozaryn A, Valente RR (2019) Livability and subjective well-being across European cities. *Applied research in quality of life* 14: 197–220. CrossRef

Papa E, Bertolini L (2015) Accessibility and transit-oriented development in European metropolitan areas. *Journal of transport geography* 47: 70–83. CrossRef

Papadopoulos E, Sdoukopoulos A, Politis I (2023) Measuring compliance with the 15-minute city concept: State-of-the-art, major components and further requirements. *Sustainable Cities and Society* 104875. CrossRef

Pazhuhan M, Shahraki SZ, Kaveerad N, Cividino S, Clemente M, Salvati L (2020) Factors underlying life quality in urban contexts: Evidence from an industrial city (Arak, Iran). *Sustainability* 12: 6. CrossRef

Piccioni C, Valtorta M, Musso A (2019) Investigating effectiveness of on-street parking pricing schemes in urban areas: An empirical study in Rome. *Transport Policy* 80: 136–147. CrossRef

Pirani E, Salvini S (2012) Place of living and health inequality: a study for elderly Italians. *Statistical Methods & Applications* 21: 211–226. CrossRef

Pontin FL, Jenneson VL, Morris MA, Clarke GP, Lomax NM (2022) Objectively measuring the association between the built environment and physical activity: A systematic review and reporting framework. *International Journal of Behavioral Nutrition and Physical Activity* 19: 119. CrossRef

Rey S (2025) Spatial inequality. *REGION* 12: 19–45. CrossRef

Rodríguez-Pose A (2020) Institutions and the fortunes of territories. *Regional Science Policy & Practice* 12: 371–386. CrossRef

Saelens BE, Handy SL (2008) Built environment correlates of walking: A review. *Medicine and science in sports and exercise* 40. CrossRef

Sallis JF, Floyd MF, Rodríguez DA, Saelens BE (2012) Role of built environments in physical activity, obesity, and cardiovascular disease. *Circulation* 125: 729–737. CrossRef

Sallis JF, Frank LD, Saelens BE, Kraft MK (2004) Active transportation and physical activity: opportunities for collaboration on transportation and public health research. *Transportation research part A: policy and Practice* 38: 249–268. CrossRef

Shrotryia VK, Singh SVP (2020) Measuring progress beyond GDP: A theoretical perspective. *Emerging Economy Studies* 6: 143–165. CrossRef

Simmie J, Martin R (2010) The economic resilience of regions: Towards an evolutionary approach. *Cambridge journal of regions, economy and society* 3: 27–43. CrossRef

Tavakol M, Dennick R (2011) Making sense of Cronbach's alpha. *International journal of medical education* 2: 53. CrossRef

Te Brömmelstroet M, Nikolaeva A, Glaser M, Nicolaisen MS, Chan C (2017) Travelling together alone and alone together: Mobility and potential exposure to diversity. *Applied Mobilities* 2: 1–15. CrossRef

Vendemmia B, Beria P (2023) When commuting is not enough: Towards a measure of territorial marginality based on job mobility. *Geographical Review* 113: 409–432. CrossRef

Verdugo MA, Schalock RL, Keith KD, Stancliffe RJ (2005) Quality of life and its measurement: Important principles and guidelines. *Journal of intellectual disability research* 49: 707–717. CrossRef

Warburton DE, Bredin SS (2017) Health benefits of physical activity: A systematic review of current systematic reviews. *Current opinion in cardiology* 32: 541–556. CrossRef

Wendling ZA, Emerson JW, De Sherbinin A, Esty DC (2020) *2020 Environmental performance index*. Yale Center for Environmental Law & Policy, New Haven, CT. CrossRef

Wiersma JK (2020) Commuting patterns and car dependency in urban regions. *Journal of Transport Geography* 84: 102700. CrossRef

Wolff P, Montaigne F, González GR (2010) Investing in statistics: EU-SILC. *Income and living conditions in Europe* 37