A New Dataset for Local and National COVID-19-Related Restrictions in Italy

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Received: 22 November 2021 / Accepted: 21 May 2022 / Published online: 3 June 2022
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Abstract
This paper presents a novel dataset of non-pharmaceutical interventions adopted by Italian authorities to tackle the COVID-19 pandemic at the national and local levels. The dataset follows the structure of the Oxford Coronavirus Government Response Tracker (OxCGRT; Hale et al. in Nat Human Behav 5:529–538, https://doi.org/10.1038/s41562-021-01079-8, 2021)). We include several novelties with respect to the original source. First, we tailor the classification of provisions to the measures adopted in Italy. Second, we collect detailed information on local restrictions in the country, including lockdowns and school closures. Third, we apply a bottom-up approach to construct population-weighted average stringency indexes (Italian Stringency Indexes, ItSIs) at the provincial, regional, and country-wide levels. While expanding the geographical coverage of the stringency indicators, we preserve the comparability of the ItSIs with the original stringency index published in the OxCGRT. As an application, we show that the correlations of our ItSI with community mobility indicators and various measures of economic activity are higher than those obtained with the OxCGRT indicator.

Keywords Covid-19 · Non-pharmaceutical interventions · Italian stringency index · Local restrictions

JEL Classification H12 · H51 · I18
1 Introduction

Since the initial outbreak of the COVID-19 pandemic, restrictive measures imposed by public authorities to mitigate the spread of the virus have profoundly affected health and socioeconomic outcomes in every country. Variables such as gross domestic product (GDP), employment, consumption, and income inequality have been impacted by the interplay of epidemic conditions, individual behaviors, and public policies, including social distancing provisions (Caselli et al. 2020; Brodeur et al. 2021, among others). One requires adequate measures of these various dimensions to analyze their mutual interactions, assess their effects on health and socioeconomic outcomes, track and forecast their evolution over time, and design evidence-informed policy responses (Hsiang et al. 2020; Abouk and Heydari 2021; de Bondt and De Santis 2021; Bonaccorsi et al. 2020; Galeazzi et al. 2021; Goolsbee and Syverson 2021; Ng 2021; Marchetti et al. 2022). In terms of restrictions, different databases and indicators have been proposed to track public responses, with the Oxford Coronavirus Government Response Tracker (OxCGRT; Hale et al. 2021) emerging as the most comprehensive database on the non-pharmaceutical interventions enacted by governments worldwide.¹ The OxCGRT also includes a widely used synthetic measure of the severity of restrictions, the stringency index (henceforth, OxSI).

The OxSI has allowed for the comparison of containment policies across a broad set of countries. Nonetheless, its ability to precisely track the actual levels of restrictions has diminished over time. In particular, after the first phase of the pandemic, many governments began to favor more localized and targeted measures over nationwide lockdowns. This shift has made it increasingly challenging to fit national-level provisions within the grid of subindicators comprising the OxSI. In this regard, Italy is no exception. To circumvent these limitations, the OxCGRT has incorporated subnational information for a set of countries (i.e., Australia, Brazil, Canada, China, India, United Kingdom, United States). However, the OxCGRT has not yet included Italy.

This paper presents a novel dataset of local and national restrictions enforced in Italy. We collect information on measures implemented in the country from official and media sources, tracing non-pharmaceutical interventions enforced by local authorities (regions, provinces, and municipalities). As in the OxCGRT, our dataset consists of two main parts. First, we map qualitative information on the restrictions from different sources as categorical variables. Second, we aggregate these categorical variables to construct summary stringency indexes (henceforth, ItSIs) at different geographic levels. Next, we analyze how the ItSI—at different geographic levels—correlates with alternative stringency indexes and with commonly used measures of economic activity.

We improve upon Hale et al. (2021) along several dimensions. First, by considering a targeted population size instead of a nationwide unweighted indicator, we can define stringency indexes at different levels of territorial aggregation (i.e., at national, regional, provincial, and municipal levels). Second, the ItSI overcomes some of the limitations² of the OxSI by introducing a richer classification of the provisions, particularly concerning the economic activities affected by the restrictions. For instance,

¹ For a short survey of other datasets tracking government response, see Appendix 1.
² See Conteduca et al. (2020) for a discussion.
we increase the level of detail by adding intermediate levels to the original scale of the primary indicators and decomposing them into more specific subindexes. Finally, our database is a unique source of geographically granular, machine-readable data that researchers can use to assess the impacts of restrictions (e.g., school closings, limitations to production activities) in Italy. The availability of such information on restrictions guarantees a high level of flexibility in constructing aggregate indicators (for instance, one could calculate the ItSI with different weights other than population, such as value-added, output, or employment). In addition to the ItSIs, the dataset includes other variables (e.g., school closures, restrictions on various types of production activities, and shops) that can be used in future studies on COVID-19’s impacts on health, economic, and social outcomes (e.g., education). Data are freely available to researchers.3

We show that during the first epidemic wave, the national ItSI tracks the OxSI closely. However, in the subsequent waves of the COVID-19 pandemic, the two indexes decouple, as provisions become increasingly differentiated across Italy. Furthermore, we also show that the correlation of the national ItSI with commonly used community mobility indicators is higher than that obtained using OxSI. Similar results are found when using different indicators of economic activity, such as quarterly GDP growth, consumption, and investment. Accurate measures of restrictions are essential for evaluating individuals’ response and compliance and disentangling the contribution of restrictions to the slowdown of economic activity.

Our paper is close in spirit to those by Cheung et al. (2021) and Gros et al. (2021). In particular, Cheung et al. (2021) propose a province-based stringency index for Canada based on the structure proposed by Hale et al. (2021). Gros et al. (2021) propose weekly and monthly stringency indexes—which we label as EuSI—throughout 2020 for 31 European countries, including Italy, that rely on national-level restriction data provided by the European Centre for Disease Prevention and Control. In the paper, we provide a comparison between our nationwide stringency index and the EuSI.

The structure of this paper is as follows. Section 2 provides an institutional background on the non-pharmaceutical interventions adopted in Italy since the outbreak of COVID-19. Section 3 describes our dataset and the construction of the ItSIs. Finally, Sect. 4 compares the ItSIs with the OxSI and the EuSI and analyses the relation between national, regional, and provincial ItSIs with available mobility and economic activity indicators at the corresponding geographical levels. Section 5 concludes.

2 Evolution of COVID-19 and Related Restrictions in Italy

This section surveys the evolution of COVID-19 in Italy and the provisions adopted by the Italian government. According to the data of Openpolis (2022), as of April 5, 2022, the central government, ministries, and other government bodies had adopted 914 regulatory acts to tackle the health, social, and economic effects of COVID-19. Figure 1 shows the evolution of lawmaking during COVID-19. The number of adopted acts exceeded 100 in a single month during the initial stage of the first wave (March 2020).

3 https://www.dropbox.com/sh/s6j0eb12ipsomc4/AAAfAeoAJch9Nf8pBUlrBNma?dl=0.
Overall, the pattern closely tracks the severity of the epidemic in the country; however, we notice that the average number of central government provisions per month decreased during the subsequent waves of the epidemic. The following subsections describe the relationship between the epidemic in Italy and related lawmaking.

2.1 Onset and First Wave

On December 31, 2019, the World Health Organization China country office was notified about cases of pneumonia of an unknown cause (World Health Organization 2020a). On January 7, 2020, Chinese health authorities identified a novel coronavirus, labeled SARS-CoV-2, as the cause of the pneumonia (World Health Organization 2020a). On January 22, the Italian Ministry of Health (MoH) published a circular with recommendations on travel to and from Wuhan, enacting screening of incoming travelers (Italian Minister of Health 2020a). On January 30, the MoH issued an order banning flights from China (Italian Minister of Health 2020d).

The first cases following community transmission in Italy were reported on February 21 in Lombardy, a densely inhabited region in the northern part of the country (Italian Minister of Health and Regione Lombardia 2020). Other cases followed in the same area and in Veneto, a neighboring region (Italian Minister of Health and Regione Veneto 2020). For this reason, the government enforced a quarantine mandate in 11 municipalities in Lombardy and Veneto on February 23 (Italian President of the Council of Ministers 2020e). Meanwhile, several public events and activities were postponed or canceled elsewhere in the country. On March 4, a new decree closed schools and suspended all public events in the national territory (Italian President of the Council of Ministers 2020j). By that date, all regions but Aosta Valley had reported at least one case.

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4 The Decree included 10 municipalities in Lombardy (Bertonico, Casalpusterlengo, Castelgerundo, Castiglione d’Adda, Codogno, Fombio, Maleo, San Fiorano, Somaglia, Terranova dei Passerini) and one municipality in Veneto (Vo’). The Decree affected about 50,000 inhabitants and forbade leaving and accessing the municipalities, banned gatherings and public events, shut down schools, closed shops, and suspended public services activities.
Rapid degradation of the leading epidemic indicators (e.g., cases, deaths, and hospital admissions), especially in the northern part of the country, induced the government to impose a national lockdown on March 10 (Italian President of the Council of Ministers 2020k). The provisions were further tightened on March 11 (Italian President of the Council of Ministers 2020l), with the suspension of retail activities and the closure of bars and restaurants, and again on March 22, when production activities of non-essential goods and services were limited (Italian President of the Council of Ministers 2020d). Furthermore, the Italian MoH prohibited citizens from leaving their municipalities (Italian Minister of Health 2020c). In just a few weeks, the restrictions proved effective in curbing the epidemic (Guzzetta et al. 2021) and reducing pressures on hospitals and intensive care units (ICUs; Fig. 2).

The decrease in infections and pressure on the National Health System (Sistema Sanitario Nazionale) allowed the government to ease the measures starting from May 4 (Italian President of the Council of Ministers 2020g). The decree reduced the restrictions on social distancing and allowed a gradual resumption of production activities. Another milestone was the reopening of retail activities, bars, and restaurants on May 18 (Italian President of the Council of Ministers 2020b). From June 3, traveling across regional borders was again permitted.

During this period, the government strengthened testing and contact tracing (Italian Minister of Health 2020e), while the number of cases remained low until mid-July.

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5 Before the national lockdown, on March 8 the government extended the quarantine to Lombardy and fourteen provinces across Emilia-Romagna, Marche, Piedmont, and Veneto (Italian President of the Council of Ministers 2020m). The interested provinces were Modena, Parma, Piacenza, Reggio Emilia, Rimini (Emilia-Romagna), Pesaro and Urbino (Marche), Alessandria, Asti, Novara, Verbano-Cusio-Ossola, Verceil (Piedmont), Padua, Treviso, and Venice (Veneto).

6 See also Barbieri et al. (2022) for an analysis of the sectors impacted by the lockdown.
Fig. 3 Epidemic evolution in Italy between July 2020 and June 2021. New cases and deaths reported in 7-day moving averages. *Hospitalized* refers to the number of people in non-critical areas. *ICU* refers to the number of people in intensive care units. Source: Authors’ elaboration, based on Italian Civil Protection Department (2020)

2.2 Subsequent Waves and the Implementation of Local Provisions

The measures adopted during the first wave of the epidemic proved effective in mitigating the epidemic in Italy. However, they exerted sizable social and economic impacts (see Bonaccorsi et al. 2021; Galeazzi et al. 2021). On April 30, the MoH adopted a set of 21 indicators to monitor and assess the epidemic risk in Italian regions and reduce the burdens associated with COVID-19-related restrictions (Italian Minister of Health 2020b). This action constituted the first step toward the adoption of regional measures.

After the restrictive measures eased in summer 2020, the number of cases began to rise again in late summer (Fig. 3). The increase of infections accelerated in the fall, inducing the government to introduce the possibility of imposing facemasks from October 8 (Italian Council of Ministers 2020a) and to tighten restrictions on bars and restaurants, as well as other services (Italian President of the Council of Ministers 2020a,c,f).

Since November 6, 2020, regions have been assigned weekly to zones depending on the 21 indicators defined in April (Italian President of the Council of Ministers 2020i). The original design established three zones with differentiated and increasing restrictions: a yellow zone with light restrictions, an orange zone with moderate restrictions, and a red zone with severe restrictions. In addition, the decree enforced a curfew on the entire country from 10 p.m. to 5 a.m. Two new decrees in December (Italian President of the Council of Ministers 2020h; Italian Council of Ministers 2020b) imposed additional restrictions for the Christmas holidays (December 24–January 6), placing the whole country in the red zone for most of that period. On January 14, a new decree introduced a further tier, the white zone, to enforce minimal restrictions (Italian Council of Ministers 2021j).

The insurgence of the Alpha variant in the country (Italian National Institute of Health 2021a) induced the government to tighten the measures between March, 15 and April 6, 2021 (Italian Council of Ministers 2021k). The new decree increased

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Marchetti et al. (2022) detail the tier system and its evolution over time.
prescriptions associated with each zone by one notch and further strengthened the measures embedded in the red zone (e.g., general school shutdown). Moreover, the decree enforced the red zone during the Easter holidays (April 3–5). This strengthened regime lasted until April 25.

Following improvements in the vaccination campaign and the consequential reduction of cases, the government issued a decree on April 22, setting the stages for the reopening of the country and establishing the grounds for the COVID-19 certificate (so-called green pass) based on vaccination, testing, or recovery from infection (Italian Council of Ministers 2021l). Further relaxation of the measures came with a new decree on May 18 (Italian Council of Ministers 2021m). An additional decree on July 23 (Italian Council of Ministers 2021a) revised the mechanism determining the tiers and introduced some restrictions for individuals without the green pass (e.g., limitations on indoor dining, public events, and services). Since September 1, the green pass has been mandatory for school staff, university employees, and university students, as well as for public transportation under some circumstances (Italian Council of Ministers 2021b). 8

A new epidemic wave beginning in July 2021 (Italian National Institute of Health 2021b) and linked to the spread of the Delta variant lasted until the fall. Over time, vaccination and testing status became the most relevant variables in determining the level of restrictions, with increased easing for vaccinated and tightening for unvaccinated individuals. On October 8, the government relaxed the constraints on the attendance of public events in white zone (Italian Council of Ministers 2021e). Since October 15, the government has mandated the green pass to access workplaces (Italian Council of Ministers 2021d). On November 26, the government extended the target of mandatory vaccination and introduced the super green pass (issued to recovered and vaccinated individuals; Italian Council of Ministers 2021g). As a consequence of the provisions adopted during this period, the distinctions among the white, yellow, and orange zones for vaccinated and recovered individuals became subtler.

At the end of 2021, the rapid takeover of the Omicron variant (Italian National Institute of Health 2022) spurred a rapid rise in cases and deaths and increased pressure on hospitals (Fig. 4). In response to the substantial increase of cases, the government adopted additional provisions (Italian Council of Ministers 2021h, i, 2022); in particular, accessing bars and restaurants required the super green pass. Moreover, the government temporarily forbade some public events, shut down clubs and discos, and extended the scope of the green pass and super green pass (e.g., access to public and private places). However, thanks to vaccination and the lower severity of the Omicron variant with respect to Delta, we observe a substantial decoupling between cases and deaths. Finally, the government announced the end of the state of emergency on March 31, 2022. 9

The tier system has led to a relevant heterogeneity of the restrictions across regions, which has been further amplified by measures enforced by local authorities. Figure 5 reports the days spent by each region in a tier between November 2020 and March

8 The Italian Council of Ministers (2021c) also extended the green pass to the personnel of kindergartens and other workers in the education sector.
9 The state of emergency started on January 31, 2020 (Italian Council of Ministers 2020c).
Fig. 4 Epidemic evolution in Italy between July 2021 and March 2022. New cases and deaths reported in 7-day moving averages. Hospitalized refers to the number of people in non-critical areas. ICU refers to the number of people in intensive care units. Source: Authors’ elaboration, based on Italian Civil Protection Department (2020).

Fig. 5 Days spent in each zone for each Italian region and autonomous province. The numbers appearing in each bar indicate the share of days spent in the respective tier. ER and FVG refer to Emilia-Romagna and Friuli-Venezia Giulia, respectively. November 6, 2020 was the date of commencement of the tier system in Italy (Italian President of the Council of Ministers 2020i). Source: Authors’ elaboration, based on orders of the Minister of Health.
3 Construction of the Dataset and Indicators

This section details the construction and content of the dataset on the restrictions enforced in Italy during the COVID-19 epidemic.

We collect data on the restrictions enforced at the national, regional, provincial, and municipal levels from official and media sources and map them in 11 policy indicators to replicate the construction of the *de iure* index proposed by Hale et al. (2021) in the OxCGRT. In doing so, we overcome some of the limitations of the original source. As highlighted in the previous section, the measures became increasingly differentiated across Italy after the first wave. While the policy indicators and the resulting index in Hale et al. (2021) rely on a binary variable indicating whether a provision applies nationwide or not, this approach is unsatisfactory for tracking geographically differentiated measures. Hence, we exploit the rich information set available to account for the share of the population targeted by each measure without losing comparability with the original source.

Table 1 summarizes the indicators describing the provisions adopted by central and local governments during the pandemic. Most indicators resemble those contained in the OxCGRT. However, to adapt our analysis to the features of the Italian regulatory framework and derive a more precise representation of the restrictions affecting economic activity, we decompose the indicator concerning workplace closing into three different subindicators: *C2_1_Production, C2_2_Shops, C2_3_BarsRestaurants*. We also tailor some variables to the specific provisions adopted in the country (e.g., *C7_InternalMovement*). All indicators save *C8_InternationalTravel* and *H1_PublicCampaigns* may target specific territories. Hence, within the context of the regulatory framework established with the November 3, 2020, decree in particular (Italian President of the Council of Ministers 2020), it is crucial to account for the size of the population facing a given level of restrictions. Besides geographical differentiation, since August 2021, the Italian government has introduced a special regime for individuals holding the green pass granted to vaccinated people or those who have tested negative for SARS-CoV-2 in the previous two days. In the construction of the indicators, we consider that a more stringent regulation applies to unvaccinated people.

Our unit of observation is municipality *m* at day *t*. Our sample includes all 7914 Italian municipalities (as of 2019) belonging to 107 provinces, each denoted by *p*, for the period January 1, 2020–March 31, 2022. We denote the 19 Italian regions and

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10 In Hale et al. (2021), 9 indicators are involved in the construction of the index: *C1_School closing, C2_Workplace closing, C3_Cancel public events, C4_Restrictions on gatherings, C5_Close public transport, C6_Stay at home requirements, C7_Restrictions on internal movement, C8_International travel controls, H1_Public information campaigns*. For more information regarding the methodology and data collection underlying the OxCGRT, see also Hale et al. (2022). We adapt *C2_Workplace closing* to reproduce in more detail the provisions adopted in Italy (see also Table 1).

11 To address in-between restrictions relatively to those presented in Table 1, we attribute intermediate values with respect to those reported in Table 1 itself.

12 For example, *C1_Schools* summarizes the following levels: (i) closure of all schools, (ii) closure of all schools but kindergartens, (iii) closure of all schools but kindergartens and primary schools, (iv) closure of all upper secondary schools only, (v) partial switch to distance learning in secondary schools, (iv) no restrictions.
Table 1  Policy indicators available in the dataset

| Variable               | Description                              | Value | Label                                                                 |
|------------------------|------------------------------------------|-------|-----------------------------------------------------------------------|
| C1_Schools             | Restrictions on in-person schooling      | 0     | No restrictions                                                      |
|                        |                                          | 0.5   | Partial remote learning in upper secondary schools                    |
|                        |                                          | 1     | Full remote learning in upper secondary schools                       |
|                        |                                          | 1.5   | Full remote learning in upper secondary schools and final two years of lower secondary schools |
|                        |                                          | 2     | Full remote learning in upper and lower secondary schools            |
|                        |                                          | 2.5   | In-person activities only in pre-school education                    |
|                        |                                          | 3     | No in-person activity                                                |
|                        |                                          | 0     | No restrictions                                                      |
| C2_1_Production        | Restrictions on in-person production activities | 1     | Remote working recommended                                           |
|                        |                                          | 2     | Mandatory remote working for most activities                         |
|                        |                                          | 3     | Shutdown of all but essential production activities                  |
|                        |                                          | 0     | No restrictions                                                      |
|                        |                                          | 1     | Limited restrictions (e.g., people allowed in stores)                |
| C2_2_Shops             | Restrictions on shops and personal services activities | 2     | Closure of some shops                                                |
|                        |                                          | 3     | Shutdown of all but essential production activities                  |
|                        |                                          | 0     | No restrictions                                                      |
| C2_3_BarsRestaurants   | Restrictions on bars and restaurants     | 1     | Dine-in allowed at some times of day                                  |
|                        |                                          | 2     | Dine-in not allowed; takeaway and delivery allowed                    |
|                        |                                          | 3     | Closure of all bars and restaurants                                  |
|                        |                                          | 0     | No restrictions                                                      |
| C3_PublicEvents        | Restrictions on in-person public events  | 1     | Cancellation of some public events                                   |
|                        |                                          | 2     | Cancellation of most public events                                   |
|                        |                                          | 0     | No restrictions                                                      |
Table 1 continued

| Variable               | Description                                | Value | Label                                      |
|------------------------|--------------------------------------------|-------|--------------------------------------------|
| C4_Gatherings          | Restrictions on in-person gatherings       | 1     | Gatherings over 1,000 people allowed       |
|                        |                                            | 2     | Gatherings up to 1,000 people allowed      |
|                        |                                            | 3     | Gatherings up to 100 people allowed        |
|                        |                                            | 4     | Gatherings up to 10 people allowed         |
|                        |                                            | 0     | No restrictions                            |
| C5_PublicTransport     | Restrictions on public transportation      | 1     | Reduced capacity                           |
|                        |                                            | 2     | Shutdown of public transport               |
|                        |                                            | 0     | No restrictions                            |
| C6_StayAtHome          | Restrictions on quarantines and isolation  | 1     | Recommended sheltering                     |
|                        |                                            | 2     | Mandatory sheltering (excluded essential activities) |
|                        |                                            | 3     | Mandatory sheltering (with very few exceptions) |
|                        |                                            | 0     | No restrictions                            |
|                        |                                            | 1     | Limited restrictions (e.g., curfew)        |
| C7_InternalMovement    | Restrictions on domestic travel and movement | 2   | No movement between regions               |
|                        |                                            | 3     | No movement between municipalities         |
|                        |                                            | 4     | No movement within a municipality          |
|                        |                                            | 0     | No restrictions                            |
|                        |                                            | 1     | Limited control (e.g., negative test)      |
| C8_InternationalTravel | Restrictions on international travel       | 2     | Mandatory quarantine                       |
|                        |                                            | 3     | Entry ban on some countries               |
|                        |                                            | 4     | Entry ban on all countries                |
|                        |                                            | 0     | No campaigns                               |
| H1_PublicCampaigns     | Presence of public information campaigns   | 1     | Public campaigns on some media            |
|                        |                                            | 2     | Coordinated campaigns on all media         |

Source: Authors’ elaboration adapting Hale et al. (2021) to the restrictions and provisions in place in Italy since January 1, 2020

two autonomous provinces with \( r \). Each region consists of some provinces, denoted by \( p \).\(^{13}\) We label the 11 indicators in Table 1 with \( i \).

To attribute a value to each indicator on a given day \( t \), we proceed in the following manner. For all days \( t \) before November 6, 2020, we attribute the nationwide value. If a

\(^{13}\) For the two autonomous provinces, province and region are equivalent.
more stringent regulation is in place in the respective region, province, or municipality on the same date, we adjust the indicators accordingly. From November 6, 2020, we attribute the level of restrictions associated with the tier of the region. If a more stringent regulation applies in the province or municipality, we adjust the indicators accordingly.

Let $v_{mti}$ be the value associated with indicator $i$ at date $t$ in municipality $m$ and $V_i$ be the maximum value of indicator $i$. We can denote the subindex $I_{mti}$ for the indicator $i$ in municipality $m$ at date $t$ as

$$I_{mti} = 100 \cdot \frac{v_{mti}}{V_i}. \tag{1}$$

Starting from August 6, 2021 and following the implementation of the green pass, we slightly modify the computation of $I_{mti}$. Different provisions may apply to individuals depending on their possession of a green pass. Let $v^g_{mti}$ and $v^{ng}_{mti}$ represent the restrictions applying to individuals with ($g$) and without ($ng$) the green pass. With $\sigma^g_{mt}$, we denote the share of individuals holding a green pass at time $t$ in municipality $m$.\footnote{By analogy, $\sigma^{ng}_{mt} = 1 - \sigma^g_{mt}$ represents the share of individuals without a green pass in municipality $m$ at time $t$.} Hence, Eq. (1) can be written as

$$I_{mti} = 100 \cdot \frac{\sigma^g_{mt} v^g_{mti} + (1 - \sigma^g_{mt}) v^{ng}_{mti}}{V_i}. \tag{2}$$

The subindicators $I_{mti}$ are then aggregated to produce a stringency index for the municipality $m$ at time $t$. In particular, the stringency index, $ItSI_{mt}$, for the municipality $m$ at time $t$ is given by

$$ItSI_{mt} = \sum_i w_i I_{mti}, \tag{3}$$

where the weights $w_i$ are equal to $\frac{1}{9}$ for all indicators except for C2_1_Production, C2_2_Shops, and C2_3_Bars_Restaurants (for this subset, $w_i = \frac{1}{27}$).

Next, we can aggregate the municipal stringency indexes, $ItSI_{mt}$, to obtain provincial, regional, and national stringency indexes. Let $s_{mp}$, $s_{mr}$, and $s_m$ denote municipal population shares relative to the province, region, and entire country, respectively. Then, we can define province $p$’s stringency index at time $t$, $ItSI_{pt}$, as

$$ItSI_{pt} = \sum_{m \in p} s_{mp} ItSI_{mt}. \tag{4}$$

Similarly, we can define region $r$’s stringency index at time $t$, $ItSI_{rt}$, as

$$ItSI_{rt} = \sum_{m \in r} s_{mr} ItSI_{mt}. \tag{5}$$
Finally, the national stringency index at time $t$, $\text{ItSI}_t$, can be defined as

$$\text{ItSI}_t = \sum_m s_m \text{ItSI}_{mt}. \quad (6)$$

We present stringency indexes in four different datasets depending on geographic scope:

1. `$restrictions_municipalities.csv$`, which includes the value of each indicator, subindex, and stringency index for each municipality and date;
2. `$restrictions_provinces.csv$`, which includes the value of the stringency index for each province and date;
3. `$restrictions_regions.csv$`, which includes the value of the stringency index for each region and date;
4. `$restrictions_national.csv$`, which includes the national value of the stringency index for each date.

Table 2 summarizes the descriptive statistics for the ItSI at the municipal, provincial, and regional levels.\(^{15}\)

In addition to these archives, we construct a panel of regional zones, starting from November 6, 2020 (`zones_panel`). Moreover, we also produce two other files:

1. `$local_restrictions_postdpcm.csv$`, which includes provinces and municipalities where stricter restrictions than those in place in the respective region apply after November 6, 2020;
2. `$local_restrictions_postdpcm_schools.csv$`, which includes provinces and municipalities where stricter school closures than those in place in the respective region apply after November 6, 2020.

Over 1700 municipalities and 28 provinces adopted stricter school closings or tier regimes than the rest of their respective regions between November 6, 2020 and March 31, 2022 (see Fig. 6). In focusing on regulations affecting specific municipalities, we find that more than 600 municipalities in Piedmont adopted more restrictive measures than those envisaged by the enforced tier in the same period. The same applies to more than 100 municipalities in Sicily, Veneto, Abruzzo, Emilia-Romagna, and Calabria. Local red zone and orange zone restrictions applied to 766 and 246 distinct municipalities, respectively. In addition, local red zone and orange zone restrictions applied to 22 and 5 provinces, respectively. Moreover, supplementary local provisions enforced (partial) school closings in 1296 municipalities and 25 provinces.\(^{16}\)

The appendix 1 decomposes the map in Fig. 6 according to the Nomenclature of Territorial Units for Statistics—level 1 (NUTS 1), which divides Italy in five distinct aggregates (Northwest, Northeast, Center, South, Insular).

\(^{15}\) We report the descriptive statistics for the national ItSI in Table 1, Sect. 4.1.

\(^{16}\) We use about 400 orders at the regional and municipal levels to construct the dataset. Some territories experienced both school closings and local orange and red zone restrictions after November 6, 2020. The file `$sources_local_restr.csv$` reports the sources used for constructing the dataset of local restrictions.
Table 2 Summary statistics for the municipal, provincial, and regional ItSIs

|                          | Municipal ITSI |                        | Provincial ITSI |                        | Regional ITSI |                        |
|--------------------------|----------------|------------------------|----------------|------------------------|---------------|------------------------|
|                          | Full sample    | Before Nov 6, '20      | After Nov 6, '20| Before Nov 6, '20      | After Nov 6, '20| Before Nov 6, '20      | After Nov 6, '20|
| Percentile               |                |                        |                |                        |               |                        |               |
| 10%                      | 27.18          | 19.44                  | 31.51          | 27.20                  | 19.44         | 31.36                  | 27.23         |
| 25%                      | 36.73          | 40.82                  | 33.31          | 36.73                  | 40.82         | 33.43                  | 36.73         |
| 50%                      | 50.31          | 51.00                  | 45.55          | 50.31                  | 51.00         | 45.77                  | 50.31         |
| 75%                      | 65.43          | 68.52                  | 64.20          | 65.43                  | 68.52         | 64.20                  | 65.00         |
| 90%                      | 79.94          | 89.81                  | 76.85          | 79.94                  | 89.81         | 69.62                  | 79.94         |
| Mean                     | 50.66          | 51.98                  | 49.86          | 50.58                  | 51.85         | 49.81                  | 50.51         |
| Std. Dev.                | 20.31          | 24.97                  | 16.81          | 20.24                  | 25.00         | 16.66                  | 20.20         |
| Observations             | 6,497,394      | 2,453,340              | 4,044,054      | 87,847                 | 33,170        | 54,677                 | 17,241        |

November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020) Before Nov 6, '20 refers to the period between January 1, 2020 and November 5, 2020 After Nov 6, '20 refers to the period between November 6, 2020 and March 31, 2022. Municipal ItSI includes 7914 municipalities. Provincial ItSI includes 107 provinces Regional ItSI includes 19 regions and two autonomous provinces Source: Authors’ elaboration
4 Results

In this section, we show how the nationwide indicator correlates with the OxSI (Hale et al. 2021) and EuSI (Gros et al. 2021). Moreover, we illustrate how the national, regional, and provincial indicators correlate with commonly used, high-frequency economic activity indicators like the Google COVID-19 Community Mobility Reports (Google LLC 2020) and Apple COVID-19 Mobility Trends Reports (Apple 2020) or the GDP, consumption, and investment (ISTAT 2022).17

4.1 Comparison with Alternative Indicators

Table 3 displays summary statistics for the two indexes. For the different percentiles, we find that the ItSI is generally lower than the OxSI. On average, the former is 17 points lower than the latter, while the median ItSI is around 50, whereas the OxSI is 71 between January 1, 2020 and March, 31 2022. The difference emerges because the

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17 See Spelta and Pagnontoni (2021) for a discussion regarding the relation between mobility indicators and industrial production.
Table 3  Summary statistics for the ItSI and OxSI

|               | ItSI Full sample | OxSI Before Nov 6, ’20 | ItSI After Nov 6, ’20 | OxSI After Nov 6, ’20 |
|---------------|------------------|------------------------|-----------------------|-----------------------|
| Percentile    |                  |                        |                       |                       |
| 10%           | 26.30            | 62.96                  | 19.44                 | 63.89                 |
| 25%           | 36.77            | 66.67                  | 41.03                 | 68.98                 |
| 50%           | 50.31            | 71.30                  | 50.59                 | 74.07                 |
| 75%           | 66.47            | 76.85                  | 68.52                 | 77.78                 |
| 90%           | 79.94            | 82.41                  | 89.94                 | 80.56                 |
| Mean          | 50.63            | 68.70                  | 51.96                 | 72.99                 |
| Std. Dev.     | 20.04            | 17.54                  | 24.87                 | 25.55                 |
| Observations  | 821              | 821                    | 310                   | 310                   |

For the OxSI, see Hale et al. (2021). November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020i) Before Nov 6, ’20 refers to the period between January 1, 2020 and November 5, 2020 After Nov 6, ’20 refers to the period between November 6, 2020 and March 31, 2022 Source: Authors’ elaboration

OxCGRGT tends to attribute the maximum level of restrictions whenever provisions are geographically differentiated. Indeed, the divergence between the two indicators substantially widened after the November 3, 2020 decree (Italian President of the Council of Ministers 2020i), which implemented the regional tier system. While in the first part of the sample, the ItSI is 10 points below the OxSI on average, the gap widens in the second part of our sample (21 points on average), with a difference of around 40 points in some weeks.

Figure 7 shows how the two indexes compare over time. The plot confirms that the two indicators are very close during the first phase of the pandemic but decouple after fall 2020. This occurs because the OxSI presents a high level of school closures at the subnational level, whereas we construct the school indicator weighting in a more granular manner. During winter, the OxSI reaches values close to those observed during the lockdown in March–April 2020. In summer 2021, unlike the ItSI, the OxSI displays a sudden increase linked to two factors: first, it reflects the implementation of some local red zones (the indicators for school closures, production shutdown, restrictions on gatherings, restrictions on internal movement, and stay-at-home orders are either close to or at the maximum, albeit with the relative flag set to 0); second, the increase of the OxSI index could reflect provisions related to the introduction of green pass regulations. However, these restrictions hold only for the minority share of unvaccinated individuals. Hence, the observed increase in the OxSI likely overstates the degree of restrictions at the national level. After September 2021, with the introduction and extension of the usage of the green pass, the ItSI decreases over time, while the OxSI remains high, despite many regions mostly being in white zone. 18

18 The OxCGRGT comprises an additional version of the index (issued on March 11, 2022, henceforth augmented OxSI), which accounts for the shares of vaccinated and unvaccinated individuals (Tatlow et al. 2022). This new version of the index is available since January 1, 2022. For Italy, the share of vaccinated affects the value of the index from January 22. The national ItSI and this augmented version of the OxSI perform similarly over the considered period and are highly correlated (0.96). In addition, the average ItSI
As a comparison, we also include the weekly version of the EuSI, the indicator proposed by Gros et al. (2021). We observe that this indicator is also close to the ItSI in terms of dynamics. However, the EuSI fails to capture some of the ongoing restrictions in the country in January and February 2020, although the two indicators are highly correlated (0.88 in 2020).

### 4.2 ItSI vs. Mobility and Economic Activity Indicators

Stringency indicators represent *de iure* indexes of restrictions. However, many other factors may influence health and socioeconomic outcomes during the pandemic. First, restrictions may affect sectors differently. Second, individuals’ responses to the restrictions may change over time. In particular, people may partly adjust their behavior by adopting protective equipment (e.g., facemasks) in relation to their sociodemographic characteristics (Papageorge et al. 2021). Furthermore, social distancing fatigue may kick in Goldstein et al. (2021), negatively affecting compliance with the norms. Measures of community mobility provided by Google (Google LLC 2020) and Apple (Apple 2020) may help to capture these other factors (Abouk and Heydari 2021). Indeed, mobility data have been extensively used in the economic literature related to COVID-19 (for example Brodeur et al. 2021; Campos-Vazquez and Esquivel 2021; Caselli et al. 2022; Fernandez-Villaverde and Jones 2020; Marchetti et al. 2022; Milani 2020). In some contributions (Buono and Conteduca 2022; Goolsbee and Syverson 2021; Mendolia et al. 2021), mobility data and indicators of containment policies have been used in combination to distinguish the effects of public interventions from those due to individual behaviors (e.g., voluntary social distancing). As such, it is essential to evaluate the relationship between stringency and mobility starting from the assumption that a more precise measure of policy restrictions should show a higher correlation with community mobility.

As reported in the documentation for the Google COVID-19 Community Mobility Reports, these indicators measure how visits to specific places change over time in

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is 12 points lower than the average augmented OxSI. Hence, the two indexes are substantially closer than the ItSI and the original OxSI.
a given geographic area with respect to a pre-pandemic baseline. Several mobility categories are included in the dataset: grocery and pharmacy, parks, transit stations, retail and recreation, residential, and workplaces.

Apple mobility data measure the volume of direction requests associated with different means of transportation per country/region compared to a baseline level of 13 January 2020.

In Fig. 8, we focus on the indicators closely related to economic activity (“G-retail” and “G-workplaces”) depicted on an inverse scale to compare with the stringency indexes. Both the ItSI and OxSI seem correlated with the mobility indicators with the expected signs: high restrictions induce individuals to reduce mobility associated with activities such as shopping, traveling and working from the office. This evidence is confirmed when examining formal time-series correlations between the stringency indexes and all available mobility indicators, except for “G-residential”, taken with the negative sign (Fig. 9). Three main pieces of evidence emerge: (1) the ItSI shows a higher correlation with the mobility indicators than the OxSI; (2) correlations between the mobility indicators and stringency indexes decrease after November 6, 2020; and (3) the reduction is more remarkable for the OxSI than for the ItSI. These results support that the ItSI provides a more precise representation of individuals’ mobility limitations than the OxSI, especially with more targeted and geographically differentiated restrictions.

The correlation between the ItSI and mobility indicators diminishes over time, albeit to a lower extent than the OxSI. Several explanations may lay behind this evidence. First, individuals may have adapted to the “new normal” by developing ways to decrease the contagion risks associated with social activity. Second, individual responses to relevant epidemic variables may have changed. On the one hand, protective devices (such as facemasks and hand sanitizer) and vaccines have become widely available, so the need for voluntary social distancing and sheltering decreased. On the other hand, lockdown fatigue may have kicked in as people have become somewhat accustomed to living with the risk of the pandemic and reduced their compliance with restrictions to mobility and social interactions. Third, the fact that governments’ limitations were more localized or targeted to specific activities than those of the first
outbreak may have reduced their impacts on mobility. The three factors most likely play some role in the observed pattern, but available information is not sufficient to gauge their relative importance.

We conclude this section by comparing the ItSI and OxSI to quarterly growth of GDP, consumption, and gross investment data provided by the ISTAT (2022) (Fig. 10). We obtain the correlations using an expanding window, with data on the macroeconomic aggregates and stringency indexes starting from the first quarter of 2020. As before, we notice that the ItSI generally exhibits a higher correlation than OxSI to the relevant economic variables. We also observe that the correlation tends to decrease over time (except for the increase observed in 2021-Q4). Finally, the correlation of the stringency indexes with consumption is larger than that with GDP and investment.

### 4.3 Subnational Stringency Indicators

Collecting local-level information on restrictions is fundamental to the construction of stringency indicators for different subnational aggregates (e.g., regions and provinces).
Fig. 10 Correlation between average quarterly ItSI, OxSI (Hale et al. 2021), Google COVID-19 Community Mobility Reports (Google LLC 2020), and GDP, consumption, and investment (ISTAT 2022) between 2020-Q3 and 2021-Q4. Quarterly GDP, consumption, and investment are in 2015 prices, are seasonally adjusted, and refer to the April 2022 edition of the national accounts. Consumption is the total household expenditure for final goods. Source: Authors’ elaboration, based on Hale et al. (2021) and ISTAT (2022)

Fig. 11 Regional ItSI and OxSI (Hale et al. 2021) between January 1, 2020 and March 31, 2022. The filled area represents the range between the minimum and maximum regional ItSIs at that date across the 19 Italian regions and two autonomous provinces. Source: Authors’ elaboration, based on Hale et al. (2021)

This aspect allows the exploitation of the cross-sectional dimension of the dataset in many potential empirical applications. The advantages compared to the original OxSI depend on the extent to which restrictions vary across territories.

Figure 11 shows the regional variability of ItSI over time, compared with the OxSI, which is available only at the national level. For the most part, the OxSI is close to the upper bound of the regional ItSIs. After November 2020, the range of regional ItSI substantially widens. The distance between the OxSI and the lowest regional ItSI (corresponding to the least strict regime) increases substantially, making the OxSI less of a good approximation for regions with low restrictions.

To gauge the ability of regional indicators to capture the territorial differences in restrictions, we consider the relationship between ItSIs and mobility indicators. Figure 12 shows box plots of the correlations of the ItSIs with mobility indicators provided by Google and Apple at the regional level in three distinct subsets: the full sample,
the period before November 6, 2020, and the one after that date. All correlations display the expected sign, generally follow the previously described patterns, and gradually fall after November 6, 2020. The more marked drops emerge for the Google workplace and grocery mobility indicators. As to the Apple indicators, we observe that the correlations are, on average, larger after November 2020 than before. Overall, these indicators also present a higher degree of variation than those provided by Google. The variation across regions is sometimes remarkable, which suggests heterogeneous responses to the measures in the different areas of the country. Similar results emerge using province-level data.

5 Conclusions

The paper describes a new dataset and indicators of COVID-19-related restrictions for Italy. We use the information contained in official sources and media releases to identify the restrictions enforced in the country at the municipal, provincial, regional, and national levels since the beginning of the pandemic. We use this comprehensive information set to construct population-weighted summary indicators of restrictiveness at different levels of geographical aggregation. This measure improves the one proposed

19 All mobility indicators but “G-residential” are taken with the negative sign.
by Hale et al. (2021) in the OxCGRT database in several aspects. In particular, our indicator shows a higher correlation with commonly used mobility indicators and crucial economic variables (such as GDP, consumption, and investment) throughout the sample.

The datasets containing raw information and summary indicators are well suited for a broad set of empirical applications for policy and academic purposes. In particular, the ItSIs allow exploiting the heterogeneity of restrictions across the territories, which has had become increasingly relevant since November 2020, when the Italian government opted for targeted and localized measures. The richness of information about school closures and restrictions on different economic activities makes the database particularly useful for researchers interested in analyzing the pandemic’s short- and long-term socioeconomic impacts.

Acknowledgements The authors thank Alessandra Allocca, Andrea Brandolini, Giovanni Veronese, Sabina Marchetti, and Simone Emiliozzi for the discussions and useful suggestions. Moreover, they are grateful to two anonymous referees for their valuable comments. Any remaining error is exclusively attributable to the authors. An early version of this paper circulated as a Bank of Italy Covid-19 Note with the title “Measuring Covid-19 Restrictions in Italy during the Second Wave” (issued on March 24, 2021, available at https://www.bancaditalia.it/pubblicazioni/note-covid-19/2021/mobility_restrictions_italy_second_wave.pdf).

Funding Not applicable.

Data availability Data available https://www.dropbox.com/sh/s6j0eb12ipsomc4/AAAfAeoAJch9Nf8pBUrlfBNma?dl=0.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

Code availability Available upon request.

Appendix A: The Tier system in Italy

This appendix briefly summarizes the evolution of the classification system for the assignment of regions to restriction tiers. Since November 6, 2020, the Italian MoH has classified each region into zones given a set of epidemic indicators. The procedure determining the level of restrictions in each area has been revised over time to accommodate varying external conditions.

Initially, the criteria focused on two main variables: scenario and risk. In particular, the Italian MoH defined four scenarios depending on the level of the net reproduction number, $R_t$, i.e., the average number of secondary cases per infectious case in a population at time $t$:

- Scenario 1: $R_t < 1$
- Scenario 2: $1 \leq R_t < 1.25$
- Scenario 3: $1.25 \leq R_t < 1.5$
- Scenario 4: $R_t \geq 1.5$
As for risk assessment, the analysis relied on measuring the probability of spread and quantifying the potential impact of COVID-19. The Italian MoH elaborated two algorithms to assess the two factors (Fig. 13, left panel for the probability assessment, and right panel for the impact assessment), using a set of ad hoc indicators (21 in total; Table 4). For the probability of spread and impact, the respective algorithm translated the relevant indicators into four distinct levels: (1) very low, (2) low, (3) moderate, (4) high. Finally, probability and impact were combined and mapped into five possible levels of risk: very low risk, low risk, moderate risk, high risk, and very high risk (Fig. 14).

The date of commencement of the tier system in the country was November 6, 2020 (Italian President of the Council of Ministers 2020i). The initial design of the system envisaged three zones: yellow, orange, and red zones. Following the weekly monitoring of risk and scenario, the Italian MoH assigned each region and autonomous province to a tier. In particular, red zone restrictions applied in the case of scenario 4 and high, very-high risk. Orange zone restrictions were enforced in the case of scenario 3 and high, very-high risk. In all other cases, yellow zone restrictions were enacted (see Fig. 15).

In January 2021, the government introduced an additional tier with mild restrictions (white zone) for areas characterized by low risk, incidence, and transmission (Italian President of the Council of Ministers 2021). Moreover, the assignment criteria introduced the weekly incidence of cases per 100,000 inhabitants as an additional parameter. Specifically, when weekly incidence was below 50 cases per 100,000 inhabitants, red zone restrictions applied only in the event of high risk and scenario 4, whereas orange zone restrictions were in effect only in the event of high risk and scenario 3. In all other cases, yellow zone restrictions were enforced with one exception: if a region was...
| Area                                      | Indicator number | Indicator                                                                 |
|-------------------------------------------|------------------|---------------------------------------------------------------------------|
| Monitoring: quality of surveillance systems and data collection | 1.1              | Symptomatic cases per month for which the onset of symptoms is known/Symptomatic cases in the same period |
|                                            | 1.2              | Cases per month requiring hospitalization (not in ICU) for which the hospitalization date is known/Cases requiring hospitalization (not in ICU) in the same period |
|                                            | 1.3              | Cases per month requiring ICU admission for which admission date is known/Cases requiring ICU admission in the same period |
|                                            | 1.4              | Cases per month for which the municipality of residence is known/Cases in the same period |
|                                            | 1.5<sup>a</sup>  | Share of long-term care facilities that have received the checklist |
|                                            | 1.6<sup>a</sup>  | Share of long-term care facilities that have reported a critical issue in the checklist |
| Testing capacity                           | 2.1              | Share of positive tests per month (possibly excluding screening or re-testing of the same individuals) |
|                                            | 2.2              | Delay between symptom onset and date of diagnosis |
|                                            | 2.3<sup>a</sup>  | Delay between symptom onset and date of isolation |
| Contact tracing, isolating, quarantining   | 2.4              | Number and characteristics of professionals and time dedicated to contact-tracing |
|                                            | 2.5              | Number and characteristics of professionals and time dedicated to testing and monitoring of close contacts |
|                                            | 2.6              | Share of confirmed cases for which contact tracing is carried out |
| Stability of transmission                  | 3.1              | Cases reported by the Italian civil protection in the last 14 days |
|                                            | 3.2              | Rt based on symptom onset or hospitalization date |
|                                            | 3.3<sup>a</sup>  | Cases reported to a sentinel system (COVID-net) in a week |
|                                            | 3.4              | Daily cases by date of diagnosis and symptom onset |
|                                            | 3.5              | Number of outbreaks (more than 2 linked cases or unexpected increase of cases in a given time and place) |
|                                            | 3.6              | New cases with unknown transmission |
|                                            | 3.7<sup>a</sup>  | Access to emergency care with symptoms compatible with COVID-19 |
| Health services availability               | 3.8              | ICU occupancy rate |
|                                            | 3.9              | Hospital bed occupancy rate |

Source: Italian Minister of Health (2020b)

<sup>a</sup> Optional indicator
characterized by low risk and was in scenario 1, white zone restrictions applied. With incidence above 50 cases per 100,000 inhabitants, red zone restrictions occurred with (at least) moderate risk and scenario 3 and scenario 4. Orange zone restrictions were implemented in scenario 2 with (at least) moderate risk or scenario 1 with high risk. In all other cases, yellow zone restrictions were in effect (see Fig. 16). The criteria were slightly modified in February 2021: when the weekly incidence was below 50 cases per 100,000 inhabitants, yellow zone restrictions were enforced in all cases but low risk and scenario 1, which triggered white zone restrictions.

On May 18, 2021, the government issued a new update to the assignment system (Italian Council of Ministers 2021m). Given the progress of the vaccination campaign and the low share of individuals requiring medical treatment after infections, the government shelved scenarios and introduced hospital bed occupancy rates as critical variables. Four different thresholds of weekly incidence were set: (1) below 50 cases per 100,000 inhabitants, (2) between 50 and 150 cases per 100,000 inhabitants, (3) between 150 and 250 cases per 100,000 inhabitants, (4) above 250 cases per 100,000 inhabitants. At the same time, three different thresholds for hospital bed occupancy rates were defined: (1) occupancy rates of ICU beds below 20% or occupancy rates of non-critical area beds below 30%, (2) occupancy rates of ICU beds below 30%
and occupancy rates of non-critical area beds below 40%, (3) occupancy rates of ICU beds above 30% and occupancy rates of non-critical area beds above 40%. With high risk, white zone restrictions were implemented when the incidence was below 50 weekly cases per 100,000 inhabitants, regardless of hospital bed occupancy rates. Orange zone restrictions were enacted when the incidence was between 50 and 150
weekly cases per 100,000 inhabitants regardless of hospital bed occupancy rates or when the incidence was between 150 and 250 weekly cases per 100,000 inhabitants, with occupancy rates of ICU beds below 30% and occupancy rates of non-critical area beds below 40%. In all other cases, red zone restrictions were enforced. With low or moderate risk, white zone restrictions were enforced when the incidence was below 50 weekly cases per 100,000 inhabitants regardless of occupancy rates. Yellow zone restrictions were implemented when the incidence was between 50 and 150 weekly cases per 100,000 inhabitants regardless of hospital bed occupancy rates or when the incidence was between 150 and 250 weekly cases per 100,000 inhabitants, with occupancy rates of ICU beds below 20% or occupancy rates of non-critical area beds below 30%. Orange zone restrictions were enacted when the incidence was between 150 and 250 weekly cases per 100,000 inhabitants, with occupancy rates of ICU beds below 30% or occupancy rates of non-critical area beds below 40%. In all other cases, red zone restrictions were in effect (see Fig. 18).

Finally, the government simplified the assignment system in July 2021 (Italian Council of Ministers 2021a). The weekly incidence and hospital bed occupancy rates became the critical variables for defining the tier in a given area. The government simplified the incidence threshold in the following manner: (1) weekly incidence below 50 cases per 100,000 inhabitants, (2) weekly incidence between 50 and 150 cases per 100,000 inhabitants, (3) weekly incidence above 150 cases per 100,000 inhabitants. Moreover, the government also redefined the thresholds for hospital bed occupancy rates: (1) occupancy rates of ICU beds below 10% or occupancy rates of non-critical area beds below 15%, (2) occupancy rates of ICU beds below 20% or occupancy rates of non-critical area beds below 30%, (3) occupancy rates of ICU beds...
below 30% or occupancy rates of non-critical area beds below 40%, iv) occupancy rates of ICU beds above 30% and occupancy rates above 40%. White zone restrictions were in effect when the incidence was below 50 weekly cases per 100,000 inhabitants regardless of occupancy rates or with occupancy rates of ICU beds below 10% or occupancy rates of non-critical area beds below 15% regardless of the incidence. Orange zone restrictions were in effect when the incidence was above 150 cases per 100,000 inhabitants, with occupancy rates of ICU beds below 30% or occupancy rates of non-critical area beds below 40%. Red zone restrictions were in effect when the incidence was above 150 cases per 100,000 inhabitants, with occupancy rates of ICU beds above 30% and occupancy rates of non-critical area beds above 40%. In all other cases, yellow zone restrictions were in effect (see Fig. 19).
Appendix B: Local Restrictions at the Municipal and Provincial Level, NUTS 1

Fig. 20  Local restrictions at the municipal and provincial level in Northwest Italy, November 6, 2020–March 31, 2022. Municipalities filled in blue denote areas with stricter school restrictions than those in place at regional levels. Municipalities filled in orange and red denote areas where orange and red zones apply, while white or yellow zones apply to the rest of their respective regions. November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020i). Source: Authors’ elaboration

Fig. 21  Local restrictions at the municipal and provincial level in Northeast Italy, November 6, 2020–March 31, 2022. Municipalities filled in blue denote areas with stricter school restrictions than those in place at regional levels. Municipalities filled in orange and red denote areas where orange and red zones apply, while white or yellow zones apply to the rest of their respective regions. November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020i). Source: Authors’ elaboration
Fig. 22  Local restrictions at the municipal and provincial level in Central Italy, November 6, 2020–March 31, 2022. Municipalities filled in blue denote areas with stricter school restrictions than those in place at regional levels. Municipalities filled in orange and red denote areas where orange and red zones apply, while white or yellow zones apply to the rest of their respective regions. November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020i). Source: Authors’ elaboration.

Fig. 23  Local restrictions at the municipal and provincial level in Southern Italy, November 6, 2020–March 31, 2022. Municipalities filled in blue denote areas with stricter school restrictions than those in place at regional levels. Municipalities filled in orange and red denote areas where orange and red zones apply, while white or yellow zones apply to the rest of their respective regions. November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020i). Source: Authors’ elaboration.
Fig. 24 Local restrictions at the municipal and provincial level in Insular Italy, November 6, 2020–March 31, 2022. Municipalities filled in blue denote areas with stricter school restrictions than those in place at regional levels. Municipalities filled in orange and red denote areas where orange and red zones apply, while white or yellow zones apply to the rest of their respective regions. November 6, 2020 was the commencement date of the tier system in Italy (Italian President of the Council of Ministers 2020i). Source: Authors’ elaboration

Appendix C: Other Datasets on COVID-19 Non-pharmaceutical Interventions

Table 5 summarizes the features of the main datasets for tracking non-pharmaceutical interventions to tackle the COVID-19 pandemic. These datasets differ in geographic and time coverage. Some of them also include synthetic indicators to measure the intensity of de iure restrictions analogous to those discussed in Sect. 4.1.20 Most datasets organize non-pharmaceutical interventions enacted in a country on a given date, so they require extensive text analysis before being embedded in any empirical analysis. Furthermore, the available alternative sources do not detail the implementation of local provisions in Italy and do not provide stringency indexes at subnational levels, unlike the dataset described in this paper. Moreover, our dataset contains information concerning the evolution of tiers across Italian regions, local school closures and provisions. In constructing our index, we also account for the existence of differentiated measures for unvaccinated individuals. In March 2022, the OxCGRT issued an augmented version of the OxSI, which also considers the share of vaccinated individuals.

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20 Other datasets appear also to have been discontinued. For an extensive list of available data sources on the COVID-19 pandemic, see also Lehner (2022).
| Name                        | Source                      | Geographic coverage                      | Time coverage         | Frequency | Targeted policies                              | Stringency index |
|-----------------------------|-----------------------------|------------------------------------------|-----------------------|-----------|-----------------------------------------------|------------------|
| ItSI datasets               |                             | Italy                                    | January 2020–ongoing  | Daily     | Containment and closure                        | Yes              |
| OxCGRT (OxSI)               | Hale et al. (2021)          | 187 countries and territories            | January 2020–ongoing  | Daily     | Containment and closure, economic policies, health system | Yes              |
| CEPS PERISCOPE (EuSI)       | Gros et al. (2021)          | European Union, United Kingdom, Switzerland, Norway, Iceland, Liechtenstein | January 2020–December 2020 | Weekly and monthly | Containment measures                         | Yes              |
| The Bank of Canada COVID’19 stringency index | Cheung et al. (2021)   | Canada                                   | January 2020–February 2021 | Daily     | Containment measures                         | Yes              |
| ACAPS                       | ACAPS (2020)                | 193 countries and territories            | January 2020–December 2020 | Daily     | Containment measures, economic policies, health system | No               |
| CoronaNet project database  | CoronaNet (2020)            | 201 countries and territories            | January 2020–May 2021 | Daily     | Containment measures, health system           | Indicators for different targeted policies |
| WHO Public Health and Social Measures | World Health Organization (2020b) | 234 countries and territories              | January 2020–ongoing  | Daily     | Containment measures, health system           | No               |
| Complexity Science Hub COVID-19 Control Strategies List | Desvars-Larrove et al. (2020) | 21 European Union countries, 10 other European countries, 36 non-European countries | January 2020–January 2021 | Daily     | Containment measures, economic policies, health system | No               |

Source: Authors’ elaboration
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