The emergence and transmission of COVID-19 in European countries, 2019–2020: a comprehensive review of timelines, cases and containment

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When it emerged in late 2019, COVID-19 was carried via travelers to Germany, France and Italy, where freedom of movement accelerated its transmission throughout Europe. However, effective non-pharmaceutical interventions introduced by European governments led to containment of the rapid increase in cases within European nations. Electronic searches were performed to obtain the number of confirmed cases, incident rates and non-pharmaceutical government measures for each European country. The spread and impact of non-pharmaceutical interventions throughout Europe were assessed and visualized. Specifically, heatmaps were used to represent the number of confirmed cases and incident rates for each of the countries over time. In addition, maps were created showing the number of confirmed cases and incident rates in Europe on three different dates (15 March, 15 April and 15 May 2020), which allowed us to assess the geographic and temporal patterns of the disease.

Keywords: COVID-19, Europe, non-pharmaceutical interventions, pandemic, SARS-CoV-2.

Introduction

A lethal viral pneumonia initially linked to animal-to-human transmission was first reported in December 2019 in Wuhan, China, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and resulting in a disease now more commonly known as coronavirus disease 2019 (COVID-19). The WHO declared COVID-19 a Public Health Emergency of International Concern on 30 January 2020. Imported cases to European Union (EU) countries via travelers from countries outside Europe contributed to the disease spreading in EU countries. The Maastricht Treaty (1993) guaranteed free movement for the citizens of Iceland, Norway, Switzerland, the UK and all European signatory countries, and this freedom of movement led to an acceleration in transmission of the disease throughout Europe. The earliest imported confirmed cases (in Finland, France, Germany, Italy, Spain, Sweden and the UK) were reported in January 2020. COVID-19 spread rapidly through Lombardy and then into Lombardy’s neighbors of Piedmont, Veneto and Emilia-Romagna. Because the ski resort of Ischgl was identified as the focus of Austria’s COVID-19 outbreak, Austrian authorities introduced restrictions on the Italian border and placed Ischgl under quarantine, to contain the spread of the outbreak. The Nordic countries of Denmark, Norway and Iceland also experienced cases resulting from tourists returning from Ischgl. Furthermore, a late suspension of European sporting events contributed to the rapid spread of the disease. For example, 2500 Valencia fans traveled to Milan to attend a Champions League football match at the very moment Lombardy was the European epicenter of COVID-19. Consequently, one third of the team and staff returning to Valencia tested positive for SARS-CoV-2. Additionally, Spanish scientists analyzing SARS-CoV-2 from Spain identified the Atlanta and Valencia football match as the most likely origin of the Spanish outbreak. The late response of the UK government to closing their borders led to 1356 independent SARS-CoV-2 lineages arriving in the UK. The majority of these early COVID-19 introductions came from three EU countries, namely, Italy, Spain
and France. Here, we conducted detailed searches of COVID-19 cases through electronic databases, local government websites and newspapers to elucidate a granular narrative and history regarding the emergence of COVID-19 in Europe in 2019 and its subsequent spread across the continent in 2020.

Methodology

Electronic searches were undertaken to obtain daily cases that were then transformed to incident cases using PubMed and Google Scholar, as well as government websites and newspapers in English and local European languages. The searches consisted of two terms used in combination utilizing the format ‘Term 1’ AND ‘Term 2’. Term 1 included ‘Covid-19’, ‘coronavirus’, ‘epidemic’, ‘pandemic’ and ‘outbreak’. Term 2 included ‘interventions’, ‘measures’, ‘cases’ and ‘case fatality’. COVID-19 data were gathered from 20 February 2020 to 31 May 2020 from EU countries, as well as the UK, Norway, Switzerland and Iceland. Daily cases were then transferred to incidence rates per 100 000 people. Government measures are included in the figures with case numbers to determine their impact on COVID-19 virus transmission in each country. Countries were categorized according to geographical region: southwest Europe; northern Europe: Germany and Nordic; the UK and The Republic of Ireland; Alps mountains: Austria, Switzerland and Liechtenstein; northwest Europe: The Netherlands, Belgium and Luxembourg; Baltic; central Europe; and Greece, Cyprus and Balkan. We created a graph for countries of low population. Countries with a population greater than 1.5 million were compared with their neighbors in a single graph. We visualized COVID-19 data by using heatmaps representing the number of confirmed cases and incidence rates for each of the countries over time. We also created maps showing the numbers of confirmed cases and incidence rates in Europe on three different dates (15 March, 15 April and 15 May 2020), which enabled us to assess the geographic and temporal patterns of the disease. Plots were created with the R package ggplot2.

The entry of COVID-19 into European countries

Prior to the Chinese travel restrictions introduced by European countries, multiple Chinese COVID-19 cases were introduced into Italy, France, Germany, the UK and Spain. Although the first reported local cases began in Italy in the second half of February, silent transmission is assumed to have begun earlier than that date. The disease spread dramatically in Germany, France, Italy, Spain, Switzerland, Belgium, Luxembourg and Iceland (Figure 1). COVID-19 entered central Europe and the Balkan states 1–2 wk after the first reported cases in western Europe. It is assumed that COVID-19 entered Poland, The Czech Republic, Hungary, Slovakia, Greece, Slovenia, Croatia, Bulgaria and Romania from western European countries (Figure 1). COVID-19 also arrived in the Nordic countries (Sweden, Denmark, Finland, Norway and Estonia) earlier than in their neighbors Latvia and Lithuania.

Three time points are shown on the map for COVID-19 outbreaks in European countries; during mid-March, COVID-19 particularly affected western Europe, while it appears that COVID-19 had not yet affected central Europe and the Balkans to the same extent (Figure 2). By mid-April, European countries from western to central Europe and the Balkans were under strict measures, consisting of either lockdown or strict social distancing measures, or a combination of both. By mid-May the European countries had started to contain COVID-19. The incidence rate declined to <5 cases per 100,000 people in all European countries by mid-May, with the exceptions of the UK and Spain (Figure 2).

The impact of COVID-19 measures on European countries

Four central European countries—Poland, The Czech Republic, Hungary and Slovakia—successfully intervened early to contain COVID-19, leading to very low levels of virus circulation. Similarly, Greece, Cyprus, Romania, Bulgaria, Croatia and Slovenia introduced measures during the first week of detected cases in each country to minimize the impact of the virus. Latvia, Lithuania and the Balkan countries responded early and succeeded in controlling COVID-19, while Estonia responded within 2 wk of the first cases and also succeeded in effectively containing the virus. In western Europe, The Netherlands, Belgium, Luxemburg, Austria and Switzerland all introduced strict measures during the third week after the first detected cases of COVID-19, while cases were increasing rapidly. Although the Nordic countries, Denmark, Finland, Norway and Iceland, only responded in the third week of the pandemic, each effectively flattened the epidemiological curve. By contrast, Sweden relied on softer and less stringent measures, while cases remained high. Germany introduced measures gradually and contained the virus effectively. In the UK, strict government measures were not introduced until 5 wk after the first week of detected cases. On the neighboring Republic of Ireland, the virus was effectively contained with an earlier intervention. The European region most badly affected by COVID-19 consisted of the southwestern countries, namely, France, Italy and Spain. Both silent transmission and a late response led to rapid increases of cases in Italy and France while the late response in Spain led to one of the worst COVID-19 outbreaks in Europe.

Southwestern European countries

After Italy reported its first local cases on 20 February, cases increased dramatically, to the extent that Italy became the epicenter of the pandemic in Europe. Of Italy’s population of 60 million, 23% are aged >65 y and, despite all the efforts made to contain the increase of COVID-19, there were >34,000 deaths in Italy after 110 d of the pandemic. France, with the largest population in southwest Europe, introduced measures 3 wk after the first cases, but deaths reached >30,000 among the French population by the end of the first wave. In Portugal, 22.4% of its 10.28 million inhabitants are aged >65 y. The Portuguese relied on early intervention to contain COVID-19 and thus avoided a catastrophic situation among their older population. By contrast, Spain introduced strict measures only after 8000 cases had been reported, at a point when there had been 300 deaths out of a population of 47 million.
Figure 1. Heatmaps representing (A) the number of confirmed cases per 100,000 people and (B) incidence rates (IR) in Europe.
(Supplementary Figure 1). Malta, to the south of Italy in the Mediterranean Sea, introduced intervention measures early in the first week of reported cases. Restrictions at the borders were applied and all returning travelers, along with people who had developed symptoms, were required to self-isolate. Public events were cancelled and schools were closed. Further measures were introduced, in which social distancing was applied and the whole of Malta was placed under quarantine. The Maltese epidemiological curve then flattened and cases decreased to <1 per 100 000 people (Supplementary Figure 2). After a cluster of cases broke out in the town of Codogno, Italian authorities placed the town under quarantine, in an attempt to contain the pandemic, but this did not prevent cases from increasing dramatically in Lombardy. The Italian government then ordered the quarantine of three Northern regions (Lombardy, Veneto and Emilia-Romagna) in an attempt to control their epidemiological curve. A rapid increase in COVID-19 cases led to the introduction of strict measures. Social distancing measures were introduced and mandated, public gatherings were cancelled and schools and universities were closed, while further restrictions at the border were introduced and returning travelers were asked to quarantine. People with COVID-19 symptoms were also required to self-isolate. The government then decided to introduce a national lockdown to contain the pandemic. Following the introduction of a national lockdown, 2 wk were required to flatten the epidemiological curve. Face masks were then made compulsory, bringing the number of cases down to 5 per 100 000 people within 2 wk (Supplementary Figure 1). The French government responded during the third week of the first detected cases of COVID-19 by cancelling public events. Then schools and universities were closed, further travel restrictions were introduced and all returning travelers were asked to self-isolate. Suspected cases were home-isolated and social distancing was introduced. A national lockdown was then introduced to contain the rapid increase in cases. After the lockdown was imposed, it took 1 wk to flatten the epidemiological curve (Supplementary Figure 1). Furthermore, a level of just 5 COVID-19 cases per 100 000 people was achieved after 2 wk of lockdown.

Thousands attended the Women’s Day parade in early March in Madrid, as well as Spanish football league matches, which continued to be held until COVID-19 cases were reported among players and spectators. The Spanish government then decided to cancel all public events in an attempt to control the sharp increase in cases. Spain introduced further restrictions at its borders, social distancing measures were applied and schools and universities were closed. A national lockdown was introduced to contain the virus. The Spanish government flattened the epidemiological curve after 3 wk of national lockdown. Cases then declined to <5 per 100 000 people after 8 wk of strict measures (Supplementary Figure 1). This relatively late Spanish intervention led to a catastrophic situation, where 250 000 COVID-19 cases and 28 385 deaths were reported after 110 d of the pandemic, approximately half of which were reported in care homes (Supplementary Figure 1). By contrast, Portugal introduced strict measures at a point when only 112 cases had been reported, thus became successful at containing COVID-19 transmission. Social distancing measures were introduced and all public events were cancelled. Schools and universities were
closed at a national level and further restrictions were applied at the border.\textsuperscript{39,40} Further measures were introduced as Portugal went into national lockdown.\textsuperscript{40} Portugal controlled the epidemiological curve after 3 wk of national lockdown. Cases then went below 5 per 100 000 people (achieving an average of just 2 COVID-19 cases per 100 000 people after 7 wk of strict measures [Supplementary Figure 1]).\textsuperscript{38} These early Portuguese interventions resulted in 43 659 cases after 110 d of the pandemic, with just 1605 deaths reported among one of the highest populations of older people in the world (Supplementary Figure 1).\textsuperscript{38}

Germany and the Nordic countries

Germany, with Europe’s largest population (83 million), introduced measures gradually.\textsuperscript{41} The government asked all people with symptoms to self-isolate, and then the German authorities cancelled all major public events to contain the virus, which had spread throughout North Rhine-Westphalia.\textsuperscript{30,41,42} Cases increased during the third week after the first detected cases of COVID-19, whereupon the German government closed schools and universities.\textsuperscript{43} Although the government introduced measures in an effort to contain super-spreader events in the first 3 wk, cases nevertheless continued to increase rapidly after 3 wk of the pandemic.\textsuperscript{62} The government then decided to introduce further restrictions at the border, along with stricter social distancing, and a national lockdown was undertaken to contain the epidemiological curve.\textsuperscript{41,42,64} After the introduction of these strict measures, Germany flattened its COVID-19 epidemiological curve in 1 wk, and after 2 wk the number of cases was reduced to <5 per 100 000 people.\textsuperscript{47} Furthermore, a federal law was introduced to make the wearing of face masks compulsory in public places.\textsuperscript{30} Among 83 million Germans, 9000 deaths have occurred and 200 000 cases of COVID-19 have been reported from the first case to the end of the first wave (Supplementary Figure 3).\textsuperscript{52}

To the north of Germany, where the Nordic countries are situated, different approaches were taken to contain COVID-19. Denmark reported a higher number of deaths compared with Norway and Finland, with 10.14 deaths per 100 000 people (Supplementary Figure 4). Denmark, Norway, Finland and Iceland all introduced strict measures from the third week of the appearance of COVID-19. However, Sweden decided to impose fewer restrictions, so that university and upper secondary school students transferred to distance learning, while primary and lower secondary school pupils were allowed to continue as normal (Supplementary Figure 4).\textsuperscript{45} Nordic countries introduced restrictions on borders and public events were cancelled. Schools and universities were closed from the third week onwards of the pandemic in all four of the Nordic countries.\textsuperscript{46–58} In Denmark, whose population is approximately 6 million, a national lockdown was introduced after a rapid increase in cases during the third week after the first detected cases of COVID-19.\textsuperscript{46–48,55} The Danish lockdown brought the virus under control after 3 wk. Furthermore, the Danish lockdown and other control measures led to achieving <2 cases per 100 000 people.\textsuperscript{55}

The Finnish government was also successful, being able to control the epidemiological curve at a level of <4 cases per 100 000 people. Denmark, which was more seriously affected by virus transmission, with the curve reaching 8 per 100 000 people. Finland introduced a regional lockdown in Uusimaa, where the country’s highest population density and capital city are situated.\textsuperscript{52,53,57,58} Three weeks after the Uusimaa quarantine was imposed, the epidemiological curve had flattened, and after 8 wk, cases had been reduced to 1 per 100 000 people (Supplementary Figure 4). After the fifth week, Finland introduced quarantine conditions for everyone aged >70 y, as Finland has one of the highest populations of older people in the world.\textsuperscript{52,57} Although 22.1% of the Finnish population are aged >65 y, the government succeeded in protecting many older people, as just 5.9 deaths per 100 000 were reported.\textsuperscript{53} More than 5 million Norwegians were placed under a quarantine order with other control measures applied in the third week after the first detected cases of COVID-19. These measures were highly effective and the epidemiological curve was flattened within 2 wk of the intervention (Supplementary Figure 1).\textsuperscript{49–51} The incidence rate reached <1 per 100 000 people after 6 wk of lockdown.\textsuperscript{56} These interventions were applied to minimize the impact of circulation of the virus and, consequently, the number of deaths among Norwegians was 4.5 per 100 000, which was relatively low compared with its neighbor Finland (Supplementary Figure 4).

In Iceland, situated in the North Atlantic with a population of only 360 000, various measures were introduced during the third week after the first detected cases of COVID-19. Self-isolation was necessary for all returning travelers and all public events were cancelled. Secondary school and university students were instructed to study from home.\textsuperscript{59–61} After the fourth week, the epidemiological curve increased rapidly when cases were detected among tourists, returning travelers and their contacts, and therefore the government introduced stricter border measures. Several deaths occurred in Vestmannaeyjar, off the south coast of Iceland, leading to the introduction of stricter measures on that island.\textsuperscript{52,61} Stricter social distancing measures were also introduced to contain the rapid increase in COVID-19 cases.\textsuperscript{64} After the Vestmannaeyjar quarantine, and the introduction of stricter border measures and social distancing measures, the epidemiological curve was brought under control within 2 wk. A level of 1 case per 100 000 people was achieved after 4 wk of the application of these stricter measures (Supplementary Figure 5).\textsuperscript{53,62,65}

In complete contrast to its Nordic neighbors, Sweden decided to opt for fewer restrictions, aiming to achieve herd immunity, a strategy which intended that at least 55% of the population would develop antibodies.\textsuperscript{66,67} Limited public gatherings, with <50 participants, were permitted, even although public gatherings had been banned by Sweden’s Nordic neighbors.\textsuperscript{68} Primary schools were closed, while secondary schools and universities were ordered to switch to online learning.\textsuperscript{65} The Swedish epidemiological curve rose to 5–8 cases per 100 000 people\textsuperscript{69} and, consequently, Sweden reported the worst COVID-19 virus transmission among the Nordic nations, with 49 deaths per 100 000 people reported after 110 d of the pandemic. This figure is far in excess of the equivalent figures for Denmark (10.14 per 100 000), Finland (5.9) and Norway (4.5).

The UK and The Republic of Ireland

Unlike the UK, The Republic of Ireland, with approximately 5 million inhabitants, introduced social distancing the second week after the first reported cases, closing schools and universities while cases still numbered <100. Public events were banned
to keep the number of cases at a low level.70–72 Because the government noticed an increase in COVID-19 cases, they introduced further restrictions at the border and required all returning travelers and those who developed symptoms to self-isolate.73 Although early intervention measures were applied, the number of cases nevertheless continued to increase rapidly.71,74 A national lockdown was then introduced to control the pandemic, even before the country had reported 1000 cases.71,74 Four weeks of lockdown were required to flatten the epidemiological curve.74 Cases then declined after 5 wk to less than an average of 5 cases per 100 000 people. The Republic of Ireland thus controlled COVID-19 and reported 1742 deaths after 110 d of the pandemic (Supplementary Figure 6).71,74

The UK response to COVID-19 pandemic was very slow and late.7 The UK government started with a ‘herd immunity’ strategy similar to Sweden’s, but pivoted soon after to suppression due to a public backlash against that policy. The British authorities asked people who developed symptoms to voluntarily self-isolate in the third week after the first detected cases of COVID-19.75 They stopped testing and tracing symptomatic individuals on 12 March. They took the decision to cancel public events very late, following an increase in cases, and this was followed by the introduction of social distancing and the closure of schools and universities.76 After approximately 8500 cases were reported, the government decided to introduce a national lockdown to contain the rapid increase in transmission.77,78 This late government response made controlling the epidemiological curve much more difficult, so that it took 5 wk to control the virus, leading to one of the worst death rates among European countries.77 The delayed response led to >44 000 deaths in the first wave of the pandemic (Supplementary Figure 6).78

Austria, Switzerland and Liechtenstein

Although Switzerland intervened earlier than Austria, cases increased in Switzerland almost twofold compared with Austria (Supplementary Figure 7).80,81 Liechtenstein, situated between Austria and Switzerland, with a population of only 38 000, reported a sudden increase in COVID-19 cases.82 Liechtenstein responded immediately in the third week, with the introduction of restrictions at the border and by asking all returning travelers to self-isolate. Public events were cancelled and all schools were closed. Social distancing was applied and all older people were advised to stay at home.83,84 It took 1 wk to flatten the epidemiological curve and control the virus, such that cases were reduced to <1 per 100 000 people after 3 wk of measures (Supplementary Figure 8).82 In Austria, with 8.86 million inhabitants, restrictions were introduced at the beginning of the third week after the first detected cases of COVID-19, with border restrictions, the closure of schools and universities and the cancellation of all public events.85,86 A quarantine was imposed in Tyrol, where the Alpine ski resorts are located, to contain the dramatic increase in cases among the local population.10 Social distancing was applied and a national lockdown was introduced to contain the sudden increase in cases.80,85,87,88 Once the Austrian government applied these measures, it took 2 wk to control the epidemiological curve (Supplementary Figure 7).80 Five weeks after the national lockdown was imposed, the Austrian government had contained the virus and cases were reduced to <1 per 100 000 people, with 705 deaths after 110 d of the pandemic.80,85

Switzerland, home to most of the United Nation institutions in Europe, was highly affected by COVID-19. Following the first reported cases, the Swiss government cancelled public events and all returning travelers were asked to self-isolate.89–91 However, cases increased in the second week, whereupon the government decided to close schools and introduced further border restrictions.90,92 Although the government introduced these measures, a dramatic increase occurred in the third week, and so they decided to introduce social distancing measures and place the country under quarantine.89,90,92 After 2 wk, the epidemiological curve was still showing >10 cases per 100 000 people (Supplementary Figure 7).81,93 Switzerland reported <1 case per 100 000 people 8 wk after the national lockdown order and 1685 deaths were reported after 110 d of the pandemic.93

The Netherlands, Belgium and Luxembourg

Although The Netherlands and Luxembourg reported COVID-19 cases earlier than Belgium, Belgium recorded one of the worst rates of COVID-19 cases and deaths among all European countries.94,95 COVID-19 cases increased rapidly during the third week after the first detected cases of COVID-19 in all three countries.94–96 Strict government interventions were introduced 3 wk after the first reported cases.97 The Netherlands, with >17 million inhabitants, was not convinced by the introduction of a strict lockdown, and so an ‘intelligent lockdown’ was introduced instead.98 Moreover, The Netherlands government decided to introduce strict social distancing measures in North Brabant to contain the rapid increase in COVID-19 cases.97 The Netherlands, Belgium and Luxembourg

Although The Netherlands and Luxembourg reported COVID-19 cases earlier than Belgium, Belgium recorded one of the worst rates of COVID-19 cases and deaths among all European countries.94,95 COVID-19 cases increased rapidly during the third week after the first detected cases of COVID-19.96,97 These national measures were introduced in the third week (while The Netherlands was reporting 5 cases per 100 000 people) and led to a flattening of the epidemiological curve (Supplementary Figure 9).97 The Netherlands implemented strict social distancing measures in the fourth week of the pandemic and the curve started to decline, 3 wk after their first intervention. Thereafter, there was <1 case per 100 000 people and the government decided to ease restrictions and reopen schools.96 Although The Netherlands eventually contained the virus, they reported relatively high mortality rates among the population, of 35 deaths per 100 000 people after 110 d of the pandemic.94

Belgium, with 11 million inhabitants, intervened during the second week after the first reported cases, while the country was reporting <2 COVID-19 cases per 100 000 people.100 Although the country imposed a national lockdown, rapid increases in case numbers were recorded in the fourth, fifth and sixth weeks of the pandemic.95,100 Although the government contained that rapid increase after 3 wk of national lockdown, Belgium reported one of the worst death rates, with >85 deaths per 100 000 people after 110 d of the pandemic.101 Effective government measures to contain COVID-19 cases then led to the country having <2 cases per 100 000 people after 8 wk of national lockdown, and the government decided to ease restrictions 10 wk after the first reported cases (Supplementary Figure 9). Belgium’s neighbor, Luxembourg, was also highly affected by COVID-19. Cases increased rapidly during the second week of the
pandemic, at which point the government decided to introduce non-pharmaceutical measures to contain the virus. A national lockdown was implemented in the third week after the first reported cases, when a sharp increase occurred. Transmission was then contained after 2 wk of government measures. Then, 6 wk after national lockdown, Luxembourg achieved <1 case per 100 000 people (Supplementary Figure 10) and decided to ease lockdown after 7 wk of restrictions. 

Baltic countries

The Baltic countries of Latvia, Lithuania and Estonia successfully flattened their epidemiological COVID-19 curves by means of early and effective interventions. Their records of very low mortality led to them being considered as among the most successful in controlling COVID-19. Latvia, with 1.9 million inhabitants, introduced early intervention measures while cases numbered <100. All returning travelers were required to self-isolate, all public gatherings were banned and border restrictions were introduced. During the fourth week, Latvia decided to introduce even stricter social distancing measures to reduce the COVID-19 curve, bringing cases down to < 1 per 100 000 people, which was achieved after just 1 wk of stricter social distancing. Latvia’s early intervention was intended to avoid overwhelming local health facilities. Latvia has 450 ICU beds, with the capacity to utilize a further 1500 beds during the pandemic to alleviate the ICU bed shortage. While the Latvian government was planning for the worst, these effective measures led to a low level of viral circulation among the community and a very low number of COVID-19 cases, with just 1110 reported during 110 d of the pandemic (Supplementary Figure 11).

The Lithuanian government also intervened effectively at an early stage of the COVID-19 pandemic, with similarly successful results. From the first week after the first reported cases, public events were banned, all returning travelers were asked to self-isolate, schools were closed, border restrictions were imposed and social distancing was introduced. A nationwide quarantine was announced during the first weeks of the pandemic, to avoid the number of cases increasing. Transmission was effectively contained in Lithuania, where 1–2 cases were reported per 100 000 people. However, the Lithuanian government was not satisfied by those achievements and so wearing a face mask was made compulsory during the fourth week of the pandemic. This effectively suppressed the epidemiological curve to < 1 case per 100 000 within 2 wk of the face-mask ruling (Supplementary Figure 11). Estonia, with 1.329 million inhabitants, intervened in the third week after the first reported cases, while Lithuania and Latvia had intervened in the first and second week after the first reported cases, respectively. The Estonian intervention followed a sudden increase in COVID-19 cases in the third week. Further restrictions on travel were installed at the Estonian border, all returning travelers were required to self-isolate, public events were cancelled, all care home visits were banned and schools were closed. Social distancing measures were introduced during the following week. Quarantine was introduced in the regions of Saaremaa and Muhumaa due to the sudden increase in COVID-19 cases (Supplementary Figure 11).

Central Europe

Poland, The Czech Republic, Hungary and Slovakia also successfully controlled COVID-19 transmission through very early intervention measures. In Poland, with approximately 38 million inhabitants, the following early intervention measures were taken: school closures, social distancing and partial lockdown, self-isolation for all returning travelers and tighter border restrictions. Poland’s stringent early interventions were made while the country was still reporting <100 cases, enabling the epidemiological curve to be maintained at a very low level, with an average of 1 case per 100 000 people. Six weeks after the first case, wearing a face mask covering became compulsory in public places in Poland, which led to keeping the epidemiological curve at an average of 1 case per 100 000 people. Thus virus transmission was contained, with 1680 deaths reported after 110 d (Supplementary Figure 12).

The Czech Republic decided to cancel all public events and to close all schools as early intervention measures, prior to the country reporting 100 cases. The Czech Republic thus prevented the spread of COVID-19 among its 10.7 million people and the government introduced social distancing measures and a national lockdown before they reported 300 cases. Further to these measures, The Czech Republic made the wearing of face masks compulsory in all public places. With the application of all these measures, The Czech Republic took just 3 wk to crush the epidemiological curve, keeping numbers below 1 case per 100 000 people, as shown in Supplementary Figure 12. Consequently, the number of COVID-19 deaths was very low compared with most other European countries, and just 336 deaths were reported after 110 d of the pandemic (Supplementary Figure 12).

Hungary introduced a range of measures prior to reporting 100 COVID-19 cases. All returning travelers were asked to self-isolate and further restrictions were introduced at the borders. Public events were cancelled and all schools were closed, in addition to the introduction of social distancing measures. Further to these measures, the Hungarian government also introduced a national lockdown 3 wk after the first reported cases, which flattened Hungary’s COVID-19 curve, reducing cases to an average of 1 per 100 000 people during the pandemic. The Hungarian government made wearing a face mask compulsory after 7 wk of the pandemic, prior to a gradual easing of restrictions. This resulted in only 4100 cases and just 572 deaths reported after 110 d of the pandemic among 9.773 million Hungarians (Supplementary Figure 12).

Strict and early intervention led Slovakia to success in confining COVID-19 cases to just 1588 after 110 d of the pandemic, with 28 deaths reported. Prior to reporting 100 cases, Slovakia had already closed schools and cancelled all public events, while all returning travelers were asked to self-isolate, restrictions were introduced at the borders and the country entered quarantine. In addition, wearing a face mask was made compulsory in public places from the third week onwards of the pandemic. Furthermore, the Slovakian government introduced a lockdown on the Roma communities and active surveillance was carried out to contain the transmission of COVID-19. After the first Slovakian case, the epidemiological curve was reduced to an average of <1 case per 100 000 people. Although Slovakia eased restrictions after 8 wk of
the pandemic, they reported a very low level of incidence per 100 000 people (Supplementary Figure 12).141

Greece, Cyprus and the Balkan countries
Early intervention measures were applied in Greece, the southern Balkans, Croatia and Slovenia in the northwest Balkans, Romania and Bulgaria in the eastern Balkans and Cyprus in the Mediterranean Sea, leading in all cases to very low levels of COVID-19. The epidemiological curves for these countries remained below an average of 2 cases per 100 000 people.148–152 Greece has one of the world’s largest populations of older people (21.9% of 10.72 million Greeks are aged >65 y) and it was one of the most successful countries in containing COVID-19 transmission.148 Greece introduced travel restrictions prior to reporting 100 cases.153 Then further restrictions were applied: social distancing was introduced, schools and universities were closed, all returning travelers were asked to self-isolate and all public gatherings were banned. The northern city of Kozani, where deaths were reported, was placed under quarantine to control the spread of infection.148,154–157 The whole country was placed under national lockdown before Greece reported 1000 cases.158 Refugee camps were also placed under quarantine once cases were detected among refugees.159 These measures helped Greece to flatten the epidemiological curve, with the average number of weekly cases remaining <1 per 100 000 people (Supplementary Figure 13).150 In Cyprus, with just over 1 million inhabitants, restrictive measures were introduced from the first week, with the cancellation of all public events and the closure of all schools.160,161 However, the number of cases continued to increase, forcing the government to introduce further border restrictions during the third week of the pandemic.162,163 These measures led to the flattening of Cyprus’s epidemiological curve, immediately after lockdown.164 COVID-19 cases decreased to <1 per 100 000 people after 2 wk of lockdown (Supplementary Figure 14).162

Croatia, with 4.08 million inhabitants, closed schools and all returning travelers were asked to self-isolate, prior to reporting 100 cases.165,166 However, a sudden increase in cases forced the Croatian government to introduce further measures and a national lockdown before 400 cases had been reported.167,168 One week of these measures flattened the epidemiological curve. Although a further sudden increase occurred, the average number of weekly cases remained <2 cases per 100 000 people (Figure 15).149 Slovenia, which borders Italy, introduced border restrictions from the first week to protect 2 million Slovenians from the virus crossing the Slovenian–Italian border close to where COVID-19 had first emerged in Europe.169 Furthermore, the Slovenian government cancelled all public events.170 However, 1 wk after the first reported case, the epidemiological curve increased sharply.150 The Slovenian government responded immediately, by closing schools and universities and introducing social distancing.170–172 Although these measures were applied, an uncontrollable increase in case numbers forced the government to impose a national lockdown during the third week.170,173 Wearing a face mask was then made compulsory in public indoor places from the fourth week of the pandemic.174 Slovenia flattened its epidemiological curve once wearing a face mask was made compulsory and the lockdown was imposed, along with other measures. The number of cases then declined to <2 per 100 000 people and then after 2 wk dropped again to <1 per 100 000 people (Supplementary Figure 13).150

Romania, with 19 million inhabitants, imposed several measures before 100 cases had been reported: social distancing was applied, all public events were cancelled and schools and universities were closed.175–177 Further restrictions were introduced at the borders and all returning travelers were asked to self-isolate.178 The Romanian government imposed a national lockdown to control the epidemiological curve at the point when 1258 cases had been reported.151,179 After the lockdown was introduced, it took 4 wk to flatten the curve. A level of 1 case per 100 000 people was reached after 6 wk of national lockdown. These measures led to 1600 deaths among its 19 million people after 110 d of the pandemic (Supplementary Figure 15).

The Bulgarian government decided to impose early intervention measures although <100 cases had been reported.152,180 Travel restrictions were introduced, public gatherings were cancelled and social distancing was applied.180,181 The government decided to close schools and universities when cases rose to >200.182 Wearing a face mask was made compulsory indoors in public places during the fifth week of the pandemic.183 Restrictions were imposed in the Bulgarian capital of Sofia, which was placed under lockdown.184 Once all these measures had been introduced, it took 2 wk to flatten the epidemiological curve. Very low incidence was reported after 5 wk of the pandemic, with just 219 deaths after 110 d of the pandemic among its 7 million people (Supplementary Figure 15).152

Discussion and Conclusion
More than 500 y ago, human plague originated in China, before Mongol armies brought Black Death across central Asia into the Crimea via ancient Silk Road routes. From there it entered Sicily before spreading across Europe.185 Similarly, human movement from China to European countries 2020 initiated the first European COVID-19 foci. Additionally, free movement between European countries exacerbated the spread of COVID-19 among EU countries, as well as the UK, Switzerland, Norway and Iceland.186 In January 2020, COVID-19 was carried by travelers from China to Italy, Germany and France.5,19,187,188 Italy was the original epicenter of the COVID-19 outbreak in Europe. COVID-19 cases were introduced from Italy to neighboring countries.15,17 The majority of COVID-19 cases introduced to Spain were associated with travelers returning from Italy.12 Moreover, multiple COVID-19 introductions from Italy, Spain and France resulted in the first COVID-19 cases in the UK.15 Furthermore, free movement between European countries led to rapid virus transmission throughout European countries. Late travel restrictions imposed by the Spanish government were possibly a major factor behind the introduction of multiple COVID-19 cases to Spain, whereas early government intervention by the Portuguese government (including travel restrictions and closing the border with Spain) controlled the level of virus transmission in Portugal.20,36 National lockdowns proved a very effective measure in all European countries where they were applied. European countries took 1–4 wk to apply a lockdown, resulting in a flattening of
the epidemiological curve in all cases. Social distancing, school closures, cancellation of all public gatherings and national lockdowns all helped to flatten the COVID-19 epidemiological curve. Germany, France, Italy, Austria, Switzerland, Norway and Estonia all reported >5 cases per 100 000 people during the peak of the pandemic, but each was able to flatten the epidemiological curve in <3 wk.17,19,42,55,80,81,108 However, Spain, The Netherlands, Belgium, Portugal and Denmark, where >5 COVID-19 cases per 100 000 were reported during the peak of the pandemic, each took >3 wk of lockdown to flatten the epidemiological curve.22,38,55,95 Similarly, it took 4 wk for each of the UK and The Republic of Ireland to flatten the epidemiological curve.74,79 Thus, Europe’s most severe COVID-19 epidemics resulted when virus transmission was allowed to accelerate for weeks before implementing lockdown or other containment measures. Similar observations were made for Chinese urban areas in January 2020, where the severity of hospital surges was determined by how quickly lockdown measures were implemented following virus importation.189 Such findings may also explain the devastating COVID-19 epidemic in New York City in March–April 2020, where virus transmission went undetected for weeks following its importation from Europe in early February.190

A high incidence of COVID-19 cases was recorded in several European countries, each with a population of <1 million. Luxembourg, Iceland and Liechtenstein each reported an average of 10–25 weekly cases because of the effect of COVID-19 on their relatively small populations.54,82,104 Two weeks of strict measures led to a flattening of the epidemiological curve in Luxembourg, Iceland and Liechtenstein.61,83,196 By contrast, Malta, with 0.5 million inhabitants, effectively restricted the number of cases to <5 per 100 000.25,26,28,191 Effective and early government response measures in some Nordic and Baltic countries (Finland, Norway, Latvia and Lithuania) led to a low weekly average number of cases during the European peak, with <5 per 100 000 people reported.49,53,55,57,106,107,118,192 Once strict government measures were applied, Finland and Norway reported <2 cases per 100 000 people, while <1 case per 100 000 was recorded in Latvia and Lithuania.48,56,112,118

Notably, wearing a face mask was made compulsory in public places in central Europe and the Balkans, which led to very low numbers of average weekly cases.126,129,145,174,181 In the central European countries of Poland, The Czech Republic, Hungary and Slovakia, as well as in the Balkan countries of Slovenia and Bulgaria, 1–2 cases per 100 000 people were reported during the European peak.124,126,133,141,150,157 Compulsory face mask wearing was introduced in The Czech Republic and Slovakia 2 wk after the first reported cases.129,145 Slovenia reported zero cases after very effective government measures in the first 3 wk, then introduced compulsory face mask wearing as an additional control measure 3 wk after the first cases.174,193 Furthermore, compulsory face mask wearing proved effective when introduced in Italy 6 wk after the first reported cases, which led to other government measures to contain COVID-19 in Italy.30 Compulsory face mask wearing was introduced in Germany 8 wk after the first reported cases, which led to limiting the number of cases to <1 per 100 000 people 3 wk after their introduction.30

The European countries with the highest percentages of older people (aged ≥65 y) are Italy (23%), Portugal (22.6%), Finland (22.1%), Greece (21.9%), Germany (21.6%), Bulgaria (21.3%), Croatia (20.9%), Malta (20.8%), France (20.4%) and Latvia (20.3%), followed by Sweden, Slovenia and Lithuania (all 20.2%), then Estonia and Denmark (both 20%).194 Effective and early intervention helped Portugal, Finland and Greece to curb the mortality rate among their older people.20,57,148 Finland introduced quarantine conditions for people aged >70 y, while Sweden reported a very high mortality rate among its older people.57,58,68,69 The Swedish government attempted a strategy with fewer restrictions and prevented care home visits in an attempt to address the mortality rate.45,66,68,69 Moreover, the sudden increase in COVID-19 cases in Italy led to a high mortality rate among older people.17 Although Spain (19.6%) and the UK (18.5%) have populations with <20% of people aged >65 y, their mortality rates were the highest among European countries as a consequence of their late interventions.22,79,194

The strategies adopted by countries in regard to containing COVID-19 are diverse. Successful East Asian countries like South Korea and Taiwan relied on the closure of their borders with China early in the pandemic instead of implementing lockdowns. Moreover, enhancing laboratory testing capability helped early case identification. Modern technology was implemented during the isolation of COVID-19 patients to help trace their contacts. Although Japan recorded the highest number of deaths in older people, the overall number of deaths related to COVID-19 was very low. Japan, without active surveillance and limited COVID-19 testing, contained the pandemic and eased lockdown measures. Very well designed strategies in the southern hemisphere countries Australia and New Zealand, where all imported cases and their contacts were traced under national lockdowns, contained the COVID-19 pandemic in both countries.62% of cases in Australia were imported while 70% of total cases in New Zealand were either imported or were related to imported cases. Early identification of imported cases supported Australia and New Zealand in rapid containment of COVID-19. COVID-19 laboratory testing enhanced active surveillance, identifying symptomatic and asymptomatic cases in New Zealand and Australia. A successful strategy to contain COVID-19 involves controlling the free movement of EU citizens, as well as those of Switzerland, Norway and the UK. Therefore, restricting free movement will be required to control future disease epidemics.

**Supplementary data**

Supplementary data are available at *International Health* online.

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