



## COVID-19 in the Netherlands: A three-phase analysis

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### ABSTRACT

**Introduction:** The COVID-19 pandemic has presented global challenges in the health, economy, society, and political sector for the past three years. For the Netherlands, the dynamic nature of the pandemic can be divided into three phases. The initial phase exclusively relied on non-pharmaceutical interventions (NPIs). The second phase was characterized by the introduction of vaccines alongside the continuation of stringent NPIs. Finally, the third phase marks the post-vaccine and booster stage, characterized by minimal or absent NPIs. This paper examines the interplay between the mitigation policies, the vaccination rollout, health outcomes, and economic indicators in the Netherlands in these three phases.

**Methods:** This analysis used national real-time data on COVID-19-related health outcomes, health service utilization, vaccination rollout, and economic indicators. Our descriptive analysis applied the “Categorising Policy & Technology Interventions (CPTI)” framework.

**Results:** The number of daily deaths, hospital admission and ICU admission experienced the highest peak in the first phase, while the number of daily cases first spiked in the third phase. The containment measures reached a very significant level twice, resulting in a full lockdown twice. In the first two phases, the peak in stringency of the CPTI containment category was parallel with the peaks in health outcomes. Conversely, in the third phase, the containment measures were scaled down prior to the peak in daily cases.

**Conclusions:** Our findings suggest that the Dutch three-phased COVID-19 mitigation strategy managed to fulfil its aim and protect vulnerable individuals, prevent healthcare institutions from overload, and move from the pandemic to the endemic phase.

### 1. Introduction

The COVID-19 pandemic has posed significant health, economic, societal, and political challenges worldwide over the last three years. These challenges have prompted the implementation of various pharmaceutical and non-pharmaceutical interventions to mitigate the pandemic's repercussions. The Netherlands, with over 8.5 million detected cases since the first COVID-19 case on February 27, 2020, is no exception [1]. The Dutch Ministry of Health (MoH) and its advisory group, the Outbreak Management Team (OMT), aimed to protect at-risk populations, prevent healthcare system overload, pursue controlled virus spread to achieve herd immunity, and manage the pandemic's dynamic nature [2]. Their mitigation decisions were based on real-time data of various epidemiological indicators, such as mortality rates, hospitalization and reproduction rates, yet not including proven indirect effects, e.g. excess mortality or mental health burden, of such measures [3–5].

Retrospectively, the dynamic nature of the pandemic can be divided

into three phases (see Fig. 1). The first phase, characterized by the absence of a vaccine focused on mitigation and prevention measures such as non-pharmaceutical interventions (NPIs) (more details in chapters 2 & 3.1), rapid expansion of ICU capacity, and gradual enhancement of testing and tracing capabilities. The Dutch authorities adopted an ‘intelligent lockdown’ approach with strict hygiene and social distancing measures but without stringent mobility restrictions. This strategy emphasized individual freedom over imposed restrictions and therefore relied on personal responsibility, differentiating it from other European countries [2,6–8].

The second phase commenced with the introduction of COVID-19 vaccines, accompanied by continued containment and prevention measures. Due to emerging virus mutations, some restrictions had to be tightened to levels resembling or surpassing those of the first phase. Studies on the Dutch vaccination strategy and related issues, such as vaccine hesitancy, demonstrated that the majority of the population preferred to observe others' experiences before receiving the vaccine

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[9–12], resulting in a slower initial vaccine uptake compared to other EU countries [13].

Lastly, the third phase represents a post-vaccine and booster phase with minimal or no NPIs. Given the decrease in vaccine efficacy against (a)symptomatic infections after 6 months, booster vaccines were deemed necessary to protect the population [14]. Despite limited evidence at that point on booster vaccine efficacy and effectiveness, the Netherlands initiated their first booster campaign in autumn 2021, following the European Medicine Agency's (EMA) recommendation for immunocompromised individuals [15]. Another revaccination round for at-risk groups occurred in autumn 2022.

To the best of the authors' knowledge, a limited number of studies assessed the three described phases with a focus on the third phase in light of eliminated NPIs and the waning of COVID-19 vaccine efficacy in the Netherlands. The majority of these studies investigate the first phase, hence focusing on the effect of NPIs, and showed that these measures effectively slowed down transmission of the virus in the Netherlands [2, 16,17]. Other studies set their focus on vaccine effectiveness and therefore just include phase two. For example, van Ewijk et al. (2022) found a moderate-to-high vaccine effectiveness against COVID-19 infections, with decreasing effectiveness over time [18]. Moreover, Gier et al. (2021) showed, in case of full vaccination, very high vaccine effectiveness against hospitalization and ICU admissions in the Netherlands, up to 20 weeks after the last vaccination [19].

Therefore, the main objective of this article is to descriptively analyze the trends, with its dynamic nature, in the Dutch COVID-19 policy in all three phases and thus to provide a comprehensive overview of the Dutch COVID-19 case. Hence, we analyze the interplay between the mitigation policies, the vaccination rollout, health outcomes, and economic indicators in the Netherlands. Following this introduction, the second section outlines the methods, followed by the findings in the third section. The fourth section discusses the findings while the last section concludes the paper.

## 2. Methods

To analyze the trends in Dutch epidemiological COVID-19 indicators, we utilize publicly available real-time data from the Dutch National Institute for Public Health & Environment (RIVM). Economic data, such as GDP and unemployment rates, are obtained from Statistics Netherlands (CBS) via open databases. To account for documentation errors, we use smoothed data variables for daily new cases and daily new deaths. Our observation period spans from the first documented COVID-19 case in the Netherlands on February 27, 2020, to the end of February 2023. For economic data, the timeframe covers the first quarter of 2020 until the third quarter of 2022. This three-year observation period enables the analysis of three pandemic phases (see Fig. 1), which are visually distinguished using vertical dotted lines:

- Phase I: February 27, 2020 to January 6, 2021; pre-vaccine with NPIs
- Phase II: January 6, 2021 to January 7, 2022; vaccine rollout (until the curve of full-vaccinated people flattened down) with significant NPIs.

- Phase III: January 7, 2022 to February 28, 2023; booster vaccine rollout with minimal or no NPIs

We descriptively analyze NPI trends using the Categorising Policy and Technology Intervention (CPTI) Framework [20]. This framework comprises four categories: policy interventions to contain the spread of the virus (Containment Measures), policy interventions for prevention and care (Prevention & Care), policy interventions to reduce the economic impact of containment measures (Economic Measures), and health technology interventions (Health Technologies). Based on various criteria, an intensity score is assigned to different measures within these categories (see Appendix 1). For example, a full lockdown with closure of non-essential stores scores very significant [4], suspension of elective surgeries scores significant [3], and deferral of taxes scores minimal[1]. The framework also stepwise categorizes deescalating measures. To identify the NPIs in place during the various stages of the aforementioned three phases, we analyze official policy letters from the Dutch Minister of Health to the House of Representatives, obtained from the national government's official website. We examine these documents for de-/escalating measures concerning the four categories and assign the respective scores (1 – 4, i.e., minimal – very significant) (for a detailed overview see Appendix 2). To visualize the stringency, development, and trends in these categories, we plot these scores in a line or bar chart. The most critical events in the different categories will be described in the results section below. For the analysis of the interplay between NPIs, health indicators, and vaccine rollout, we only consider the CPTI Containment measure category.

## 3. Results

The results section is divided into five subsections. The first four subsections reveal the policy and technology interventions, the vaccination rollout, health outcomes, and economic indicators in the Netherlands during the three defined phases respectively. The fifth subsection combines findings from the first four findings to provide a broad overview of the interplay between CPTI, epidemiological indicators, and vaccination rollout.

### 3.1. Non-pharmaceutical interventions during the three phases

Fig. 2 illustrates the four CPTI categories in the Netherlands during the observation period. A detailed overview of all implemented NPIs in the three phases can be found in Appendix 2. Panel A displays the containment measures. In response to the first wave in 2020, the government declared an "Intelligent lockdown," which relied on the individual responsibility of citizens and so remained non-essential stores open and shopping by appointment was allowed. Afterwards, the Netherlands implemented a full lockdown twice (intensity score 4). In the subsequent full lockdowns, which took place during the transitions from phase one to two and from phase two to three, these stores were required to close to control viral spread. Throughout the three phases, regional and national borders were never officially closed. Currently, after the end of phase three, no general recommendations or measures regarding COVID-19-specific hygiene and social distancing are in place

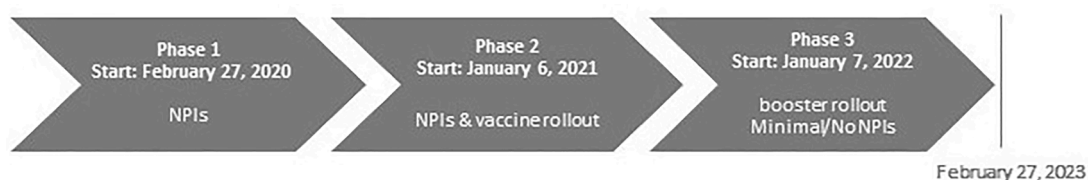
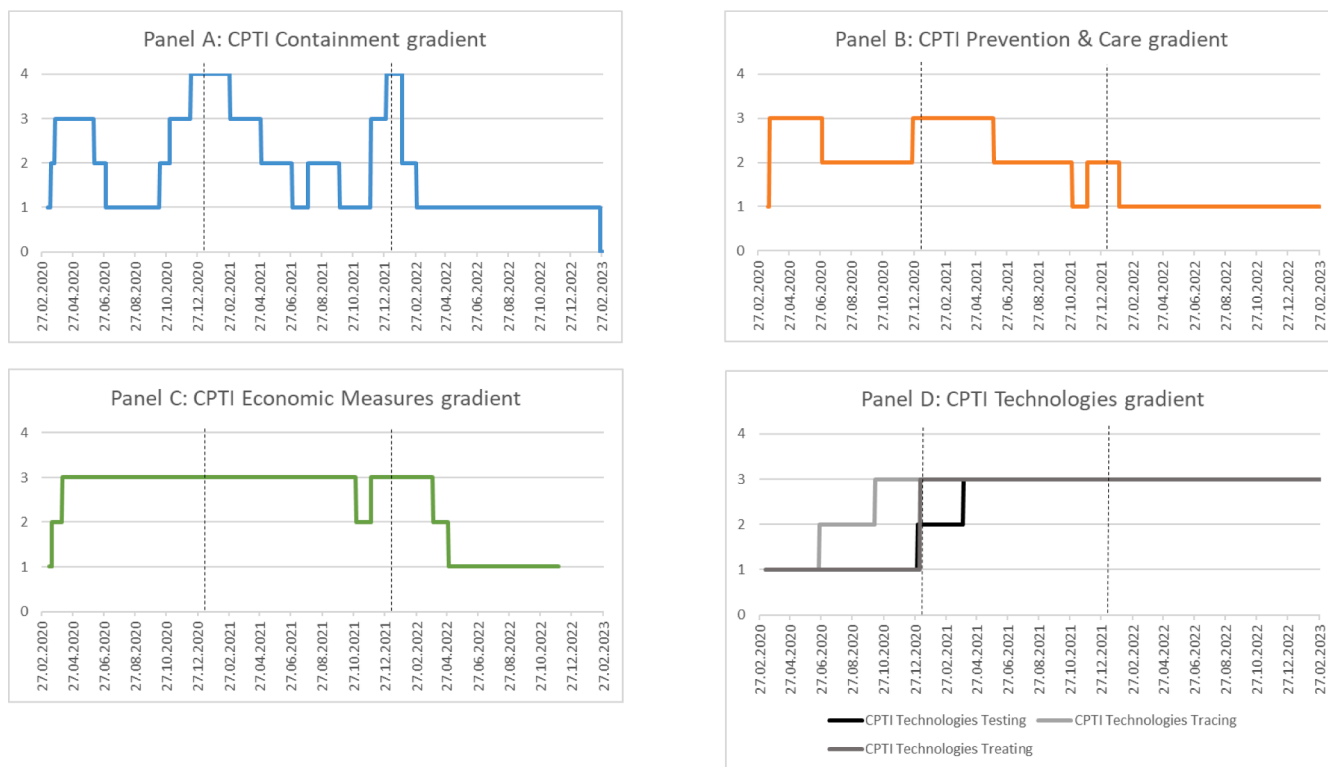


Fig. 1. Three phases of the Dutch COVID-19 mitigation strategy.  
Source: Authors' own illustration



**Fig. 2.** CPTI intensity scores in the Netherlands during the observation period.

**Source:** Authors' own illustration based on data retrieved from official policy letter from the Ministry of Health, Welfare and Sport to the national government (see [Appendix 2](#) for detailed overview).

[21].

Panel B depicts the CPTI Prevention & Care category. This category immediately rose to level 3 due to a rapid increase in ICU capacity from 1,150 to 2,400 beds. However, elective care (e.g., cancer screenings, hip/knee replacements) was also postponed during phase one. To catch up on postponed elective care and remain available for COVID-19 patients, ICU capacity remained expanded in phases two and three. In the beginning of phase two, regular care was reduced to accommodate COVID-19 care. To increase resilience in crises, the MoH decided that ICU capacity, along with the ability to quickly scale up, needed to be permanently expanded and improved. Therefore, the CPTI score remains 1.

Panel C showcases the Economic Measures, which began with a deferral of tax payments and progressed to financial support packages for entrepreneurs, self-employed individuals, and companies in the event sector. Several financial crisis interventions were implemented to provide this support [22]. Along with other measures to improve testing capacity, medical treatment options, and financial bonuses for health professionals, the total additional spending related to COVID-19 is estimated at 88 billion euros (2020 - 2023) [22]. The general financial support packages for the aforementioned sectors were set to expire in phase two. However, due to increasing containment measures that affected entrepreneurs, self-employed individuals, and businesses in the events sector, support packages were reintroduced and extended until the beginning of phase three. Currently, at the end of phase three, some small financial support measures remain in place and work retrospectively to compensate affected entrepreneurs.

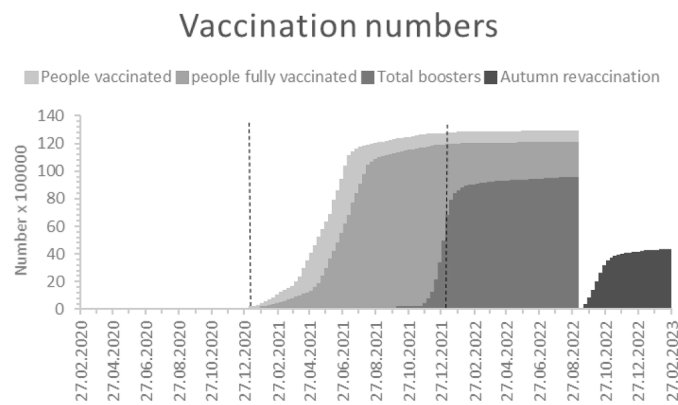
The testing system, with existing testing techniques, expanded slowly due to capacity limitations (see [Fig. 2](#), Panel D). Similarly, the tracing system grew slowly, as it relied mainly on human resources. Nevertheless, this category reached a significant level in phase one with the introduction of a central tracing organization. Furthermore, a tracing application, "CoronaMelder," was developed after a nationally

organized "hackathon" in phase two. However, this app never gained much popularity, mainly due to concerns about privacy, usefulness, and consequences of the application [23]. Approximately 6 million people, about 35% of the population, downloaded the app, which has been inactive since October 2022 [24]. In the beginning of phase two, antigen self-tests became available, elevating the Testing subcategory to a significant level. The Treating subcategory reached a significant level in phase two when advanced treatments for infected individuals were developed.

### 3.2. Vaccination rollout

Regarding the vaccine rollout, the very first vaccine, developed by BioNTech/Pfizer, was administered on January 6, 2021, as shown in [Fig. 3](#). This event marked the beginning of the second phase in combating the COVID-19 virus. Priority was given to employees of direct COVID care, nursing homes, small-scale residential facilities, disability care, and district nursing services, followed by residents of these institutions. Subsequently, at-risk groups (over-60 s and medical risk groups) still living at home became eligible for vaccination. The eligible group was then gradually expanded according to the year of birth. By the beginning of October 2021, everyone aged 12 and older was able to receive their first shot. By the end of phase two, nearly 12 million people were fully vaccinated, accounting for approximately 78% of the Dutch population aged 12 and older (see [Fig. 3](#)).

Additionally, towards the end of phase two, a booster vaccine campaign commenced, with nearly 9.5 million people receiving their first booster. The RIVM recommended everyone aged 12 and older who had completed the basic vaccination series to receive a revaccination at least 3 months after the last vaccine, infection, or booster. In the second part of the third phase, the next round of booster vaccinations began. This revaccination was advised for individuals at a medical (high) risk of severe illness and death from SARS-CoV-2 infection. This group includes



**Fig. 3.** The vaccination rollout in the Netherlands.

**Source:** Authors' own illustration based on data retrieved from the public database from the National Institute for Public Health and the Environment (RIVM)

persons aged 60 years and older, residents of long-term care facilities, and those with an indication for influenza vaccination (aged 12 years and older). Four million people received their second booster vaccine.

### 3.3. Covid-19 epidemiological trends

Fig. 4 shows the data on infections (Panel A), mortality (Panel B), hospital admission (Panel C) and ICU admission (Panel D) over the three phases. The number of daily deaths, daily hospital admissions and daily ICU admissions peaked in phase one. The highest reported number of deaths per day was 154 (Panel B). The highest number of daily-admitted hospital patients to the general ward was 3,284. For the intensive care units, the peak of COVID-19 patient admissions was at 1,424 patients. The maximum amount of daily reported smoothed cases was in phase three with 125,321 (Panel A). Moreover, a downward waving trend over the three phases in the number of daily deaths and daily ICU patients is observed (Panels B and D).

### 3.4. Economic indicators

With regard to the selected economic indicators, it is evident that the significant containment and prevention measures affected the Dutch GDP. In the second quarter of 2020, in phase one, the GDP decreased considerably by 8.7% compared to the second quarter of 2019, and the downward GDP trend continued during the rest of phase one, as shown in Fig. 5. From Q2 of 2021 onwards, including phases two and three, the GDP started to grow again compared to the previous year despite the implemented containment and prevention measures which were employed at a very significant level[4] in both phases, as shown in Fig. 2 Panel A and B.

Furthermore, during the first phase, the Netherlands witnessed a rise in the unemployment rate, primarily affecting short-term unemployment (less than one year), as shown in Fig. 6. The peak in the total unemployment rate occurred in July 2020 (Q3), with 5.5% of the population aged 15 to 75 being unemployed. From that point onward, the unemployment rate declined to 3.2% in April 2022 (Q2), which is below the average unemployment rate of the past 20 years (mean 6%). Since then, the unemployment rate has fluctuated around 3.5%.

### 3.5. The interplay between CPTI, covid-19 epidemiological indicators, and vaccination rollout

The interplay between NPIs, COVID-19 health outcomes, and the vaccination rollout in light of the aforementioned three phases reveal interesting insights into the relative effectiveness of such interventions. In the upcoming subsection, these interesting observations will be

discussed and structured according to the three phases as described in the methods parts and are depicted in Fig. 7, Panel A to D.

#### 3.5.1. Phase I

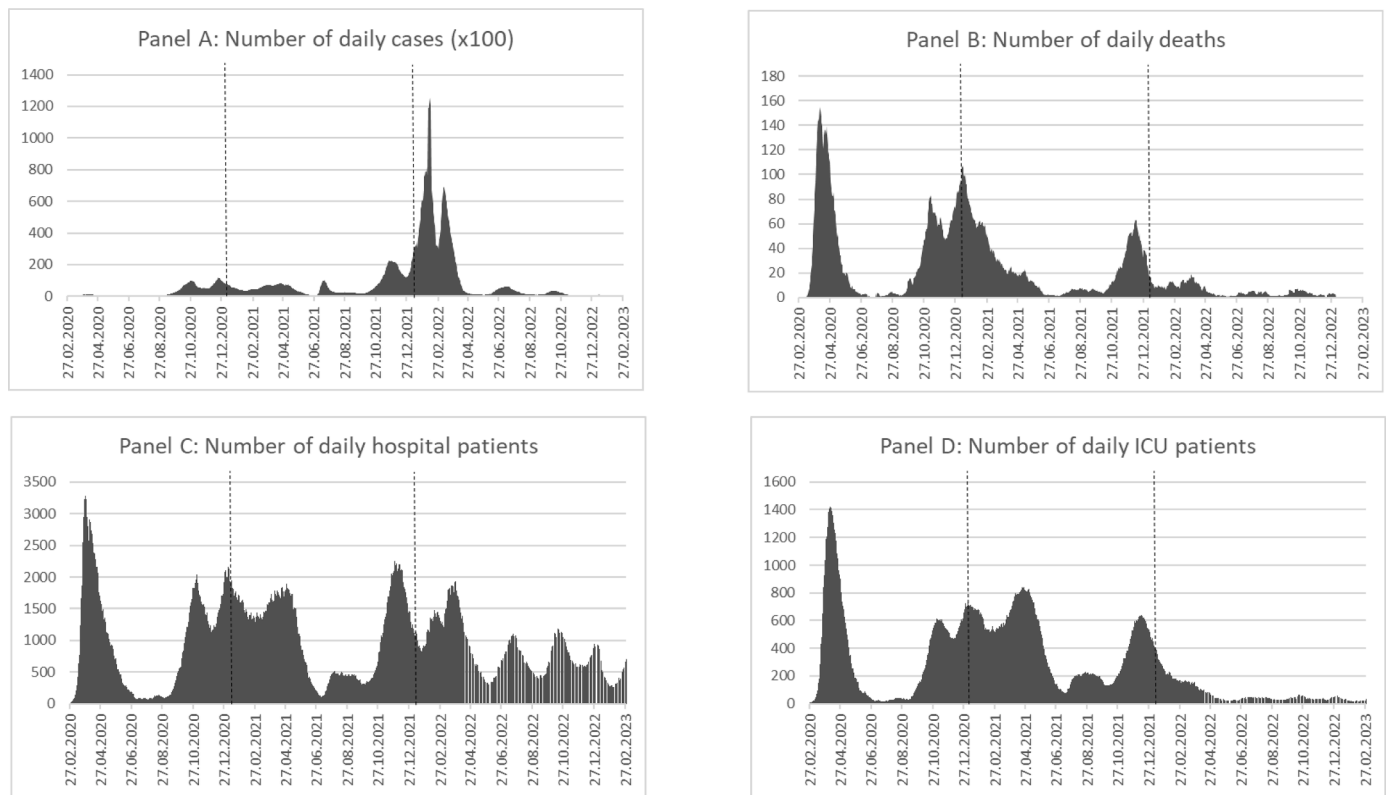
During the first phase, peak levels of the CPTI containment measures coincided with the apex of daily mortality rates, hospital, and ICU admissions. These containment measures were gradually reduced following a significant decrease in the aforementioned indicators (See Fig. 7, Panel B-D). Throughout the summer months, all four indicators maintained low-level stability. In the latter part of the first phase, specifically during the autumn months, a resurgence was observed in the previously mentioned three indicators. In response, the CPTI containment measures were consequently amplified.

In contrast to the initial surge in phase one, the subsequent peak was shorter, less severe, and promptly mitigated by containment measures. Nevertheless, even after the commencement of a decline in mortality rates, hospitalizations, and ICU admissions, there was a further increase in CPTI containment measures. This led to a divergence in the trajectories of the CPTI containment and epidemiological indicators (see Fig. 7, Panel B - D), although the latter never fell to the baseline. As the transition from phase one to phase two occurred, containment measures were heightened, culminating in the implementation of the first comprehensive lockdown. Despite the intensification of containment measures aimed at curbing an escalation in mortality and hospital/ICU admissions, these indicators experienced another surge during the transition from phase one to phase two.

#### 3.5.2. Phase 2

During phase two, as the rollout of COVID-19 vaccines progressed and immunization rates increased, the CPTI containment measures were progressively eased. Notably, a surge in hospital and ICU admissions occurred when approximately 25% of the population aged 12 and above had received their first vaccine dose. This peak, however, was not paralleled by a similar increase in daily deaths or case numbers. Even amidst rising hospitalizations and ICU admissions, the lockdown was lifted, and daily deaths continued on a declining trajectory. This trend led to a wide-ranging wave with three peaks in hospital and ICU admissions from the culmination of phase two until the onset of phase three (see Fig. 7, Panel C&D). In contrast, the number of daily deaths only exhibited two peaks during this wave.

Midway through phase two, during the summer months, hospital and ICU admissions trended upwards, culminating in a minor peak. Concurrently, daily case numbers maintained a low-level plateau, while daily deaths only saw a slight uptick. By this juncture, over 75% of the population had received their first vaccine dose, prompting a modest tightening of the CPTI containment measures to a medium level.



**Fig. 4.** COVID-19 health indicators in the Netherlands: infections, mortality, hospitalizations, and ICU admissions. **Source:** Authors' own illustration based on data retrieved from the public database from the National Institute for Public Health and the Environment (RIVM)

Following this peak in hospital and ICU admissions, the CPTI containment measures were scaled down to a minimal level. Despite this, these two indicators did not significantly descend to the graph's baseline. Toward the end of phase two, another surge in hospital and ICU admissions, as well as daily deaths, was observed. Although these peaks were lower than those in the preceding phase, containment measures were escalated from a minimal to a significant level at the apex of these indicators. This period also marked the commencement of the first booster campaign. By the end of phase two, while daily deaths, hospital admissions, and ICU admissions were on a downtrend, daily case numbers were on the rise.

### 3.5.3. Phase 3

Upon the commencement of phase three, a second full lockdown was announced and implemented. Daily case numbers continued to ascend, but containment measures were moderated to a medium level just prior to the peak. When more than 50% of the population aged 12 and above had received their booster vaccine, a steep decline in daily cases ensued, and containment measures were further relaxed to a minimal level. This was shortly followed by a brief, milder surge in daily case numbers and hospital admissions.

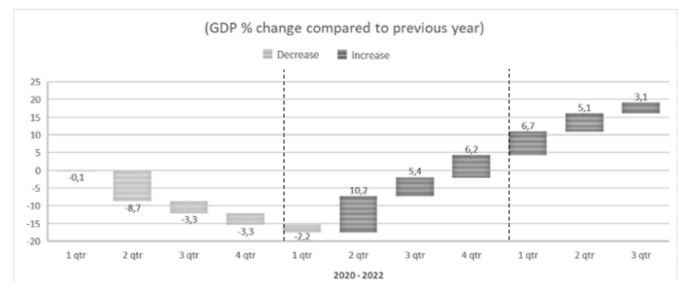
From this point until the conclusion of phase three, containment measures persisted at a minimal level, while daily case numbers, mortality rates, and ICU admissions stabilized at low levels. Daily hospital admissions demonstrated a fluctuating trend, although a decreasing pattern emerged midway through phase three with the initiation of the second booster campaign. On the final day of phase three, CPTI containment measures were fully relaxed to a "none" level, signaling the cessation of specific COVID-19 restrictions.

## 4. Discussion

Our analysis of the three phases of the Dutch COVID-19 mitigation

strategy and its impact on various health and non-health-related outcomes reveals that (very) significant containment measures were crucial in all three phases to protect vulnerable individuals and prevent healthcare institutions from becoming overwhelmed. However, the first two phases showed that the peak in stringency of the CPTI containment category was parallel with the peaks in deaths and hospital and ICU admissions (Fig. 7, Panels B-D). In fact, the NPIs, and in the second phase the vaccination rollout, did not prevent spikes in these COVID-19 epidemiological indicators from occurring and therefore did not directly fulfill the aim in the first two phases.

From the onset of phase three, this pattern appeared to deteriorate. The CPTI containment measures were scaled down despite a peak in the daily cases and hospital admissions. By examining the vaccination numbers during this pivotal period (transition of phase two to phase three), we observed the commencement of the first booster vaccine rollout. The Dutch government made the prudent decision to advance



**Fig. 5.** GDP percentage change in the Netherlands during the three-phase pandemic.

**Source:** Authors' own illustration based on data retrieved from the public database from Statistics Netherlands (CBS) (Data set: GDP (Volume) – year-on-year % change)



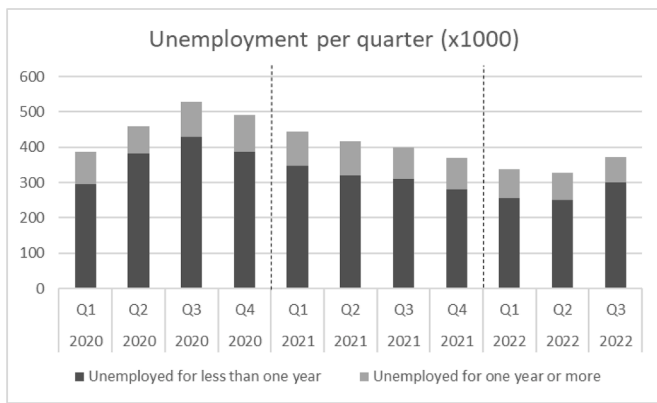


Fig. 6. Unemployment status during the three-phase of the COVID-19 pandemic.

Source: Authors' own illustration based on data retrieved from the public database from Statistics Netherlands (CBS) (dataset: "Unemployed workforce")

and accelerate the booster campaign due to the upcoming annual infectious disease season and the emergence of various mutations [25], despite approximately 80% of Dutch people having already completed full vaccination. This resulted in a situation where over 50% of the 12 years+ population had received a booster vaccine, the daily cases and hospital admissions spiked but the number of daily deaths and ICU admissions followed a downward trend and stabilized at the bottom. Therefore, the CPTI containment measures could be scaled down to a minimal level. Hence, it seems effective to revive immunity with the use of booster vaccines to prevent COVID-19 disease and ICU admission and

COVID-19 infection and mortality during the course of the third phase, ensuring the resilience of the healthcare system.

Recently, the Dutch government announced it would no longer differentiate COVID-19 from other respiratory viral infections and eliminated all COVID-19 specific guidelines to prevent infections [21]. Instead, they emphasized general hygiene measures when managing flu and cold symptoms. This shift underscores the fading presence of the COVID-19 pandemic and suggests that the Netherlands is capable of managing the virus effectively and move from the pandemic to the endemic phase. In other words, following the three phases, the Netherlands has developed the capacity to shield its citizens and healthcare institutions from the heightened risks associated with the COVID-19 virus.

During the course of the three phases of the COVID-19 pandemic, several factors have contributed to the current policy approach adopted by the Netherlands. Firstly, over the time the Dutch MoH and the OMT were able to establish adaptive policies based on real-time data. Effective adaptive policies require comprehensive data encompassing the natural history of the pathogen, relevant epidemiological information, and data on the efficacy of NPIs [26]. With the developed Corona Dashboard the RIVM and Rijksoverheid collected this data to quicker adjust the policy measures to the current situation. Another aspect, which showed adaptive governance, is the rapid expansion of intensive care capacity. Within the initial months of the first phase, the ICU capacity was doubled. This measure played a vital role in supporting the implementation of the "intelligent lockdown" during the first phase, allowing for partial societal functioning and the continued operation of the economy [27].

Besides and maybe even more important, the Dutch population developed herd immunity<sup>1</sup> to the COVID-19 virus, and its mutations, in

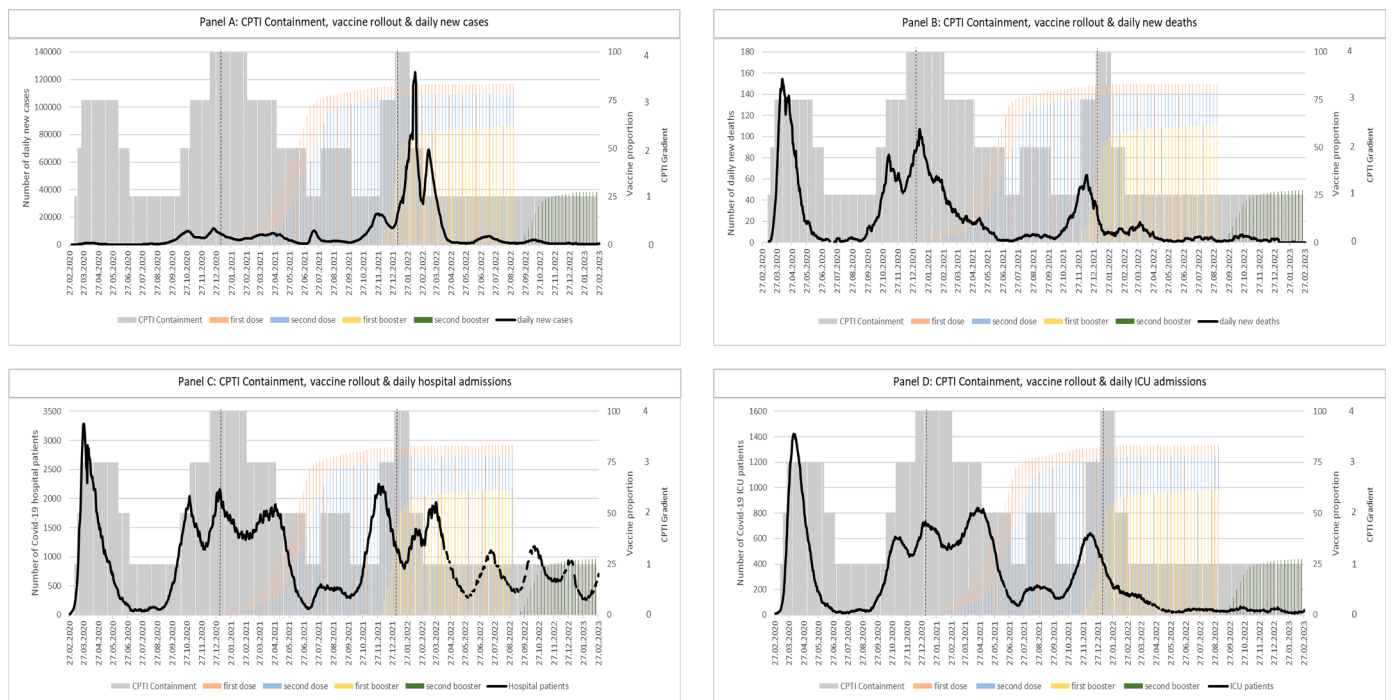


Fig. 7. Trends in CPTI Containment gradient, vaccine rollout (%) & Covid-19 Health Indicators\* over the three phases.

\*Panel A = daily new cases, Panel B = daily new deaths, Panel C = daily COVID-19 hospital patients, Panel D = daily COVID-19 ICU patients. Source: Authors' own illustration based on data retrieved from the public database from the National Institute for Public Health and the Environment (RIVM)

thus protect at-risk people and healthcare systems. Additionally, the absence of peaks in daily deaths and ICU admissions since the second booster campaign, despite fluctuations in daily hospital admissions, underscores the protection of the Dutch population against severe

<sup>1</sup> Herd immunity is the indirect protection from infection conferred to susceptible individuals when a sufficiently large proportion of immune individuals exist in a population (28).

the past three years. The establishment of herd immunity reduces the necessity for stringent containment measures to control the spread of the virus. For the COVID-19 virus, the herd immunity threshold (HIT) is estimated at 67%, although this value can vary depending on population structure, transmission dynamics, and the duration of immunity [28]. However, relying on natural infection as a means to achieve herd immunity was not considered a viable strategy to combat the COVID-19 pandemic, as a substantial portion of the population would have been exposed to severe illness, particularly among vulnerable groups [29,28]. Mass vaccination programs were implemented to expedite the establishment of herd immunity and provide protection to these high-risk groups. This approach was also observed in the Netherlands. Since the vaccination campaign against the COVID-19 virus and the booster campaigns for the different mutation, it appears that the HIT has been passed in the Netherlands. This resulted in diminishing containment measures to safeguard at-risk groups and health care institutions. Therefore, COVID-19 vaccination campaigns are effective to protect the health care system, the at-risk groups and minimize its socioeconomic impact.

Due to the comprehensive impact of the COVID-19 virus, the Dutch economy also experienced significant consequences, mainly in the first phase. The GDP decreased significantly compared to the year before with around 15% (see Fig. 6), despite the “intelligent lockdown” in the first phase which aimed to limit societal costs caused by a lockdown [30, 27]. This decline is higher than expected at the onset of the pandemic, where the OECD estimated a GDP loss of around 6.7% [31]. The socioeconomic impact of COVID-19 is also evident in the unemployment rate, which initially increased during the first phase, primarily driven by short-term unemployment. This trend aligns with similar observations in other countries such as Germany and the UK [32], and can be attributed to the implementation of social distancing measures, particularly the closure of bars, restaurants, and non-essential businesses [31–33]. It is noteworthy that the GDP started to recover in the beginning of phase two (see Fig. 5), and the unemployment rate gradually decreased toward the end of the first phase (see Fig. 6), despite the ongoing minimal to very significant NPIs. The relatively early turnaround in unemployment rates can be assigned to the financial support packages for these sectors and businesses [34], creation of new jobs [35] and the adaptation to home-based work and the release of NPIs [36,32],[31]. Consequently, the overall effects on the labor market appears to be less severe than during an economic recession [34].

#### 4.1. Policy implications

After more than three years since the onset of the COVID-19 pandemic, valuable lessons have been learned and should be considered in the fight against future infectious disease outbreaks, which are likely to occur sooner than later, as suggested by One Health experts [37]. Previous infectious disease outbreaks, such as the SARS outbreak and influenza pandemic, have already demonstrated the large health and socioeconomic impacts of such outbreaks [38,37]. National governments have followed recommended prevention, control, and mitigation strategies to combat the virus, and adapted their strategies based on real-time health and healthcare system data, such as cases, deaths, and hospital admissions [39]. However, retrospectively, other factors besides only epidemiological indicators of the COVID-19 virus (e.g. mortality rates, hospital admission numbers, etc), are important to take into account for future infectious disease control strategies, mainly considering the indirect effects of containment measures.

Indirect health effects of the COVID-19 pandemic occur due to delayed and/or avoided urgent, elective medical care and showed in previous epidemics greater impacts on health than the infectious disease itself [40]. In various countries the number of excess deaths cannot only be assigned to COVID-19 infections [41,2,42]. Delayed or avoided care can have a significant impact on morbidity and mortality rates for various diseases. In the Netherlands, it is estimated that one out of five

individuals reported avoiding health or medical care during the COVID-19 pandemic [43]. Approximately one-third of these patients would benefit from urgent medical evaluation of their symptoms, such as cancer screening, as delayed diagnosis often leads to the disease being diagnosed at a more advanced stage. For instance, a modeling study in England examined the effects of the pandemic-induced delays in cancer screening and diagnostic tests on patient survival up to five years. According to the study, the increases in death rates ranged from 7.9% to 9.6% for breast cancer, 15.3% to 16.6% for colorectal cancer, 4.8% to 5.3% for lung cancer, and 5.8% to 6.0% for esophageal cancer [44]. Another modelling study on the effect of disruption of cancer screenings in the Netherlands showed supporting results, and stated the impact on mortality can be reduced with a catching-up strategy when restarting the screenings [45].

Another indirect effect of the COVID-19 pandemic are mental health problems shown in an increase in anxiety to get infected, and due to social isolation, and concerns about an insecure future [46]. Studies have shown that in the first stages of the COVID-19 pandemic individuals were still resilient and no or little change in symptoms of depression, anxiety, stress or other mental health problems have been found compared to pre-pandemic levels [47,48]. However, over time, especially for vulnerable population groups (e.g. patients with a psychiatric disorder, COVID-19 diagnosed patients, health care workers, children and adolescents, pregnant women, and elderly people) this resilience was challenged and the COVID-19 pandemic did impact mental health outcomes for these groups [47,49]. This resulted in a substantial mental health burden (in form of quality adjusted life years (QALY) losses) related to COVID-19 containment measures.

Therefore, it would be advisable to include indicators on delayed and avoided care, as well as mental health indicators as a key performance indicator for a control strategy of an infectious disease. As mentioned earlier, the Dutch containment strategy was effective in fulfilling their aim of protection healthcare institutions for overwhelming and at-risk group for COVID-19 infections. However, other at-risk or vulnerable groups may have fallen victim to this strategy.

## 5. Conclusion

In sum, after three years of COVID-19 response in the Netherlands, we can state that the Dutch three-phased strategy with firstly just severe NPIs, a combination of severe NPIs and the first vaccine rollout afterwards and lastly revaccination with minimal NPIs is, in the course of time, effective in protecting healthcare systems and at-risk groups. With population immunity against the COVID-19 virus and the permanently increased ICU capacity, the health care system appears resistant to the COVID-19 virus. It resembles the transition from the pandemic to the endemic phase in the Netherlands. This permanent capacity increase can possibly avoid disrupted and delayed medical care and the indirect excessive mortality in the reaction on infectious disease outbreaks in the future. Moreover, in the future a broader set of outcome indicators should be considered when examining a containment strategy, since the impact of policy interventions to a viral outbreak covers a broader perspective than just those directly affected by the virus.

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**CRedit authorship contribution statement**

**Declaration of Competing Interest**

**Anouk van Amerongen:** Conceptualization, Methodology, Data

None declared.

**Appendix 1**

Framework by Moy et al. [20] *Categorising Policy & Technology Interventions (CPTI) to a viral outbreak*. The four policy intervention categories and the severity score including criteria

	Minimal (1)	Medium (2)	Significant (3)	Very Significant (4)
<b>Policy interventions to contain the spread of the virus:</b> these interventions focus on containment, mitigation and elimination practices to change behaviors.	intervention for containment interventions is one which is not mandated by law, such as a government recommendation to work at home if possible, and hygiene messages	Intervention for containment are those which are mandated by law, however, no fines are imposed to enforce behavior. For example, the closing of schools or the declaration of a state of emergency	include those that are mandated by law and enforced, such as the closure of borders, restrictions on social distancing or enforced quarantines	are the complete restrictions on movement on the populace and all non-essential industries are shutdown
<b>Policy interventions for prevention and care:</b> these interventions focus on the country’s healthcare system and in particular on the resourcing ability to treat active cases.	interventions those which increase the capacity of the healthcare system such as provision of additional healthcare equipment	capacity increases are those that affect medical staff, such as redeployment or early graduation of eligible students	response is one that has a larger impact on the healthcare system and incorporates private healthcare resources, such as the suspension of elective services or the use of private facilities for provision of public healthcare	All healthcare related resources devoted to the public healthcare system to respond (suspension of elective surgery, suspension of private insurance premium)
<b>Policy interventions to reduce the economic impact of containment measures:</b> these are fiscal interventions used to reduce the economic impact of the pandemic.	Minor market intervention by the government. Main: Bonuses, credits, tax relief/deferrals from the state/county/council level, rent freezes	Moderate government intervention in the market. Main: Funding for specific industries or sectors and specific individuals (families or sole traders only) plus minimal economic interventions	Major government intervention in the market. Main: Extraordinary increase of public spending for industry bailout and quantitative easing plus medium economic interventions. E.g. Industry bailout (large funds), relief cheques, liquidity, interest rate adjustments, wage subsidisation	Full government intervention in the market. Main: Suspension of free-market and shift toward central planned economy
<b>Health technology interventions:</b> these are the innovative technological responses of industry and governments and health research systems to assist in testing, tracing and treating individuals with the virus. All focus on health monitoring and potential pharmaceutical treatments for viruses.	<b>Testing</b> (Objective based criteria: confirming, exploring, expanding) Nasopharynx swab test (RT-PCR)	Blood serology testing	Investments in new testing technology (i.e. new technology - different from PCR; more accurate and faster tests)	
	<b>Tracing</b> (Degree of invasiveness of the technology) Using existing tracing technologies for COVID-19 (E.g. Use of call centres; Symptom tracker app; COVID-19 tracker teams)	Decentralised contact tracing using new technology (Contact tracing through GPS/Bluetooth tracking (not provided to government), detecting COVID-19 in sewage)	Centralised contact tracing using new technology (E.g. Contact tracing through GPS/Bluetooth tracking (provided to government), Artificial intelligence to detect population risk groups)	
None = Human to human contact, standard ICU, no use of PPE etc. for COVID-19	<b>Treating</b> (The extent of advancement of technology) Human to human contact with limited protection (E.g. Use of PPE, temperature checks)	Intensive/Hospital care: respirator advancements (new modifications and types); technology use for managing viral cases (new apps etc.); extensive telehealth	Drug repurposing (proven outcomes); robots; compulsory use of telehealth	Vaccine



Appendix 2

Overview of implemented NPIs during the three phases in the Netherlands with the assigned CPTI score per category

Year	Month	Day	Measure (description)	Containment measures	Prevention & Care measures	Economic measures	Health Technology Interventions		
							testing	tracing	treating
2020	February	27	First Covid-19 Case the Netherlands						
	March	1	<b>Status quo CPTI</b> First National Measures: people from risk area need to stay home when having symptoms	0	0	0	0	0	0
		6	First Covid-19 Death in the NL People from Noord-Brabant need to stay home when having symptoms						
		9	Hygiene measures + stop shaking hands	Minimal (1)					Minimal (1)
		11	World Health Organization declares COVID-19 as pandemic						
		12	Stay home with symptoms, avoid social contact, 100+ pax events cancelled, work from home, online education Deferral of payments Tax	Minimal (1)			Minimal (1)		
			Testing high risk patients with symptoms					Minimal (1)	
		15	Closure schools, gastronomy and fitness. 1.5 m social distancing. Extension current measures until 6th of April	Medium (2)					
		16	Discontinue population-based cancer screening (till 28th of April)		Minimal (1)				
		17	First economic support packages for entrepreneurs and self-employed			Medium (2)			
		20	ICU capacity expansion + reemployment retired medical staff + military staff and resources applied in public system		Sig (3)				
		23	Intelligent Lockdown; current measures + cancellation all events, professionals with physical contact need to close. Shops and public transport need to regulate distancing. 'Stay home as much as possible'	Sig (3)					
		31	Extension All Covid measures	Sig (3)					
	April	1	<b>Status quo</b>	Sig (3)	Sig (3)	Medium (2)	Minimal (1)	None (0)	Minimal (1)
		6	Current measures extended to 28th of April IC beds scaled up to 2400 bed Extension economic support measures				Sig (3)		
		29	Most current measures extended till 19th of may Children below 13 can train outdoor sports again						
May	1	<b>Status quo</b>	Sig (3)	Sig (3)	Sig (3)	Minimal (1)	None (0)	Minimal (1)	
	11	Stay home with symptoms! primary education and childcare partly reopens Professionals with physical contact are allowed to work when no symptoms Outdoor sports allowed (18+ with 1.5 m distance), also cultural youth clubs are allowed to reopen (outdoors) Extension testing capacity to professionals with physical contact							
June	1	<b>Status quo</b>  relaxation of measures (in gastronomy, cultural sector, group building) with strict conditions (1.5 distance mainly) Mask mandation in public transport Nationwide testing for people with mild symptoms	Sig (3)	Sig (3)	Sig (3)	Minimal (1)	None (0)	Minimal (1)	

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Year	Month	Day	Measure (description)	Containment measures	Prevention & Care measures	Economic measures	Health Technology Interventions		
		8	Priming system for full length school capacity	Medium (2)			Minimal (1)		
		23	Process all the positive tests Detection virus in sewage water				Medium (2)		
	July	1	<b>Status quo</b>  1.5 meter distance remains the norm reopening gyms, wellness, casino, canteens "Group building" up to 100pax (inside) & 250 (outside) Travel/holiday is possible under restrictions restart population cancer screenings. ICU capacity stays scaled up	Medium (2)	Sig (3)	Sig (3)	Minimal (1)	Medium (2)	Minimal (1)
	August	1	<b>Status quo</b>	Minimal (1)	Medium (2)	Sig (3)	Minimal (1)	Medium (2)	Minimal (1)
		6	Permanent ICU bed increase, separated for clinical patients and Covid patients						
		10	regionally more control and measures to maintain social distancing and hygiene measures (e.g. enforce closure of busy places)						
		18	work from home is the norm Always a fixed seat indoors Up to 6 guests at home						
	September	31	All schools are open						
		1	<b>Status quo</b>	Minimal (1)	Medium (2)	Sig (3)	Minimal (1)	Medium (2)	Minimal (1)
			Compliance with basic rules/measures (hygiene, social distancing, quarantine) Nightclubs remain closed						
		20	Regional measures concerning opening hours gastronomy and maximum amount of people in groups (50pax)						
		28	Activities outside a maximum of 40 people and indoors 30 people in one room Groups should not exceed 4 people Gastronomy closes at 10.00 p.m.						
	October	1	<b>Status quo</b>	Minimal (1)	Medium (2)	Sig (3)	Minimal (1)	Medium (2)	Minimal (1)
		10	Launch Corona Tracing App						
		14	Partial Lockdown (closing gastronomy, Events are banned, alcohol purchases and consumption between 22.00 and 07.00 is prohibited, restrictions on sport events, mask mandation educational institutions)	Medium (2)				Sig (3)	
	November	1	<b>Status quo</b>	Medium (2)	Medium (2)	Sig (3)	Minimal (1)	Sig (3)	Minimal (1)
		3	extension Lockdown Do not travel abroad unless necessary. smaller group building, restrictions for sports	Sig (3)					
	December	17	Continuation Partial Lockdown						
		1	<b>Status quo</b>	Sig (3)	Medium (2)	Sig (3)	Minimal (1)	Sig (3)	Minimal (1)
		8	Indoor mask mandation						
		14	Continuation Partial Lockdown Full lockdown (gastronomy closed, Events prohibited, All non-essential stores closed, alcohol prohibited after 8 p.m., distance learning)	VSig (4)					
		24	Scaled up IC bed count + cancelation of class 4 and 5 care to continue acute care		Sig (3)				

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Year	Month	Day	Measure (description)	Containment measures	Prevention & Care measures	Economic measures	Health Technology Interventions		
2021	January	1	<b>Status quo CTPI (Lockdown, schools closed, economic support and recovery packages, Scaled-up bed count + scaling down of class 4 and 5 care)</b>	VSig (4)	Sig (3)	Sig (3)	Medium (2)	Sig (3)	minimal (1)
		6	First vaccine health care workers elderly houses						
		12	continuation Lockdown until February 9th						
			continuation Scaled-up bed number + scaling down of class 4 and 5 care						
		18	First corona vaccination for residents of nursing home and disability care facilities						
		21	expansion of economic support and recovery package						
		23	Curfew 21:00 until 4.30						
		29	AstraZeneca vaccine accepted						
		February	2	<b>Status quo CTPI</b>	VSig (4)	Sig (3)	Sig (3)	Medium (2)	Sig (3)
		8	primary education and childcare, with the exception of the out-of-school care (BSO) reopen consumers can pick up pre-placed orders, at pre-arranged times, at the store, called "click & collect"						
		23	continuation Lockdown & Curfew. relaxations from 1st of March onwards						
		24	Widening of the Fixed Charges Allowance						
		26	New drug (with antibodies casirivimab and imdevimab) approved to treat Covid 19 patients						
	March	1	<b>Status quo CTPI</b>	Sig (3)	Sig (3)	Sig (3)	Medium (2)	Sig (3)	Sig (3)
			Reopen high-schools one day a week. Professionals with physical contact can work again.						
		3	shopping with appointment. Outside sport until age of 27.						
		12	expansion of economic support and recovery package						
		14	Pause dosing of vaccine AstraZeneca						
		16	Play outdoor sports with up to 4 people ages 27 and older						
		18	Resumption of dosing of vaccine AstraZeneca						
		19	emergency measure Countermeasure Entrepreneurs Affected Sectors COVID-19 (TOGS) is being finalized						
		23	Start dosing Johnson and Johnson vaccines non-critical plannable care scaled down and treatments deferred to create capacity space to accommodate the continued inflow of COVID patients						
		31	postponing curfew with 1 h (starts 22:00) The first corona self-tests are publicly available					Sig (3)	
	April	1	<b>Status quo CTPI</b>	Sig (3)	Sig (3)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		2	temporary pause of vaccination with AstraZeneca vaccine in persons under 60 years of age after a report of thrombosis						
		8	AstraZeneca vaccine to be used only in people aged 60 and older						
	12	scaling down of some treatments in critical plan care (cancer related surgery, or transplantation)							
	19	after-school care (bso) open again for all children							
	26	Allow physical higher education (college and university).							

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Year	Month	Day	Measure (description)	Containment measures	Prevention & Care measures	Economic measures	Health Technology Interventions		
	May	28	<b>status quo CTPI</b> Home visitation advisory is in place to limit the number of people per playgroups, sports, and other activities. In addition, the maximum number of people per playgroups, sports, and other activities is limited to 10 people. In addition, the maximum number of people per playgroups, sports, and other activities is limited to 10 people. In addition, the maximum number of people per playgroups, sports, and other activities is limited to 10 people.	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		19	IC beds is scaled down to 1350 - more resources to regular care (and recovery opportunities for medical personnel) (regular IC capacity was 1150)		Medium (2)				
		26	expansion of economic support and recovery package						
		27	next step of "opening plan" is announced and will put in place at the 5th of June. Introducing "Proof of vaccine, test or recover" (e.g. Corona access cards) to expand releasing measures regarding events with fixed seats						
		28	<b>status quo CTPI</b>	Medium (2)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
	June	1	End of lockdown						
		5	Expanding hospitality options - opening restaurants under special conditions working from home is and remains the norm						
		18	Announcement of step 4 in "open-up plan" for the 26th of June						
		26	Basic measures remain (1.5 m distance, hygiene recommendations, getting tested in case of symptoms, isolate until test results) Work at the office 1 day a week No restrictions on group sizes When 1.5 m distance can be guaranteed events until 100p allowed <b>without</b> "corona certificate" (restaurants, culture etc.). Mask mandation for indoor places expires Nightclubs and events without seats are allowed <b>with</b> "corona certificate"	Minimal (1)					
		30	vaccinate young people as young as 12 with the BioNTech/Pfizer vaccine						
	July	1	<b>status quo CTPI</b>	Minimal (1)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		6	Stay alert, rise in case can be possible after relaxation of measures						
		9	Very quick raise in morbidity -> put containment measures in place again 1.5 m distance in gastronomy, with fixed seats Closing times 00.00 tot 06.00 "testen voor toegang" (access testing) will be paused (Bigger) events need to follow the 1.5 m distance rule and fixed seats -> no events without fixed seats allowed financial support and recovery package extended	Medium (2)		Sig (3)			
		19	Work at home unless there is no other way travel outside of rush hour provide plenty of fresh air	Medium (2)					
		26	No multiple day festivals until 1st of September						
		28	financial support event sector extended						
	August	1	<b>status quo CTPI</b>	Medium (2)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		13	With corona certificate are 1day events, without fixed seats for max. 750pax allowed						
		30	Relaxation 1.5 m rule in higher education						

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Year	Month	Day	Measure (description)	Containment measures	Prevention & Care measures	Economic measures	Health Technology Interventions		
			Other containment measures of 9th of July stay in place						
		31	General financial support and recovery package extended to max. 1st of October.						
	September	1	<b>status quo CTPI</b>	Medium (2)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		14	Everyone aged 12 years and older had the opportunity to be vaccinated						
		25	1.5 m distancing rule expires Corona certificate required for gastronomy, cultural and sports activity	Minimal (1)					
			Closing times 00.00 tot 06.00 remains Mask mandation for public transport work at home when possible and in the office when necessary						
	October	1	<b>status quo CTPI</b>	Minimal (1)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
			ICU capacity scaled down to 1150.		Minimal (1)				
	November	1	<b>status quo CTPI</b>	Minimal (1)	Minimal (1)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		6	escalation containment measures 1.5 m distancing (indoors) back in place working at home at least 50% of working hours extension mask mandation (public areas, on platforms and contact occupations) extension of corona certificate (outside terraces, amateur sports from the age of 18, and choirs and other cultural associations.)						
			General financial support and recovery package extended due to increasing measures and impact on many sectors						
		10	Covid 19 hospital is scaled up, planned care is scaled down		Medium (2)				
		12	partial lockdown max 4 guests (13+) at home work from home is the norm 1.5 m distancing (indoors and outdoors when there is no corona certificate) Closing hours (20.00 - 06-00 for gastronomy and non-essential retail stores, 18.00 - 06.00 for events -> except events with fixed seats) no crowd at sport games maximum group size in higher education	Medium (2)					
		28	Closing hours extended (17.00 - 05.00) except essential retail and service providers Extending 1.5 m rule and mask mandation (e.g. schoolteacher and high school kids)	Sig (3)					
	December	1	<b>status quo CTPI</b> Flight ban High Risk countries imposed (southern Africa)	Sig (3)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		14	Extension current measures until 14th of January closing school week before Christmas holidays						
		19	Lockdown only 2 visitors (on holidays 4) Closure gastronomy Closure non-essential retail and events non-professional sports paused	Vsig (4)					
2022	January	1	<b>status quo CTPI</b>	VSig (4)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	Sig (3)
		10	reopening of primary and secondary schools outdoor sports until 17 years until 20.00 o'clock	Sig (3)					
		14	reopening non-essential retail (with mask mandation)						

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Year	Month	Day	Measure (description)	Containment measures	Prevention & Care measures	Economic measures	Health Technology Interventions			
			restart of professions with physical contact (e.g. hair dressers) (with mask mandation)							
			ICU capacity scaled down to 1150.		Minimal (1)					
		25	Non-critical planned care scaled down							
			reopening gastronomy (with corona certificate) (5.00 am - 10.00 pm)	Medium (2)						
			reopening cultural and leisure events/ locations (corona certificate and mask indoors)							
	February	1	<i>status quo CTPI</i>	Medium (2)	Minimal (1)	Sig (3)	Sig (3)	Sig (3)	Sig (3)	
		18	closing times are extended (01.00 am - 05.00 am)							
			With corona certificate are 1day events, without fixed seats for max. 500pax allowed							
		25	general closing times dropped	minimal (1)						
			Test for access for events bigger than 500 pax							
			fixed seat is no longer mandatory							
			corona certificate no longer required in restaurants, cinemas and musea							
	March	1	<i>status quo CTPI</i>	Minimal (1)	Minimal (1)	Sig (3)	Sig (3)	Sig (3)	Sig (3)	
		23	Mouth mask public transport dropped							
			Testing for access expires							
			No corona certificate mandation for travelling to NL							
			Basic measures remain (1.5 m distance, hygiene recommendations, getting tested in case of symptoms, isolate until test results)							
			Keep promoting working from home							
	April	1	<i>status quo CTPI</i>	Minimal (1)	Minimal (1)		Sig (3)	Sig (3)	Sig (3)	
			generic financial support package ends April 1, 2022				Sig (3)			
	May	1	<i>status quo CTPI</i>	Minimal (1)	Minimal (1)	Medium (2)	Sig (3)	Sig (3)	Sig (3)	
		30	Last official policy update on public corona time line website							
			Hygiene measures							
			Testing,							
			isolation when positive							
			Ventilation							
			Vaccinate!							
	<b>Final Status CTPI</b>			<b>Minimal (1)</b>	<b>Minimal (1)</b>	<b>Medium (2)</b>	<b>Sig (3)</b>	<b>Sig (3)</b>	<b>Sig (3)</b>	<b>Sig (3)</b>

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