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Bachelor Thesis

The evolution and current state of COVID-19 Dashboards in Europe

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Abstract

The aim of this thesis is to create and analyze a dataset that documents the information published on official Covid-19 government dashboards. It adds to the already existing literature by also considering temporal components. The dashboards were documented semi automatic based on old snapshots saved by the internet archive. Based on the created data set, the thesis presents a ranking of the countries, a comparison of the different indicators and country specific timelines containing the dates of the dashboard adaptations and the dates of important key events in the pandemic. Of the 26 countries covered, Austria, Belgium, the Czech Republic and Germany offer the most comprehensive dashboards. The chronological analysis of the case dashboards shows which countries were pioneers in the creation of the dashboards and which countries were able to orient themselves on the templates of the others.

1 Introduction

On 30. January 2020 the World Health Organization (WHO) declared Covid-19 as a public health emergency of international concern. Only two months later the WHO recharacterizes the emergency as a pandemic. Most governments responded with the implementation of non-pharmaceutical interventions (NPIs) consisting of different public health and social measures to prevent the spread of Covid-19 and reduce its burden on the health system. Most NPIS, which are suitable to counter a virus like Covid-19, are severely restrictive and cause enormous economic and social costs [15]. To plan and justify the implementation of such measures, countries had to inform the population about the current state of the ongoing pandemic. As a result, countries began to publish increasingly more Covid-related data, such as the number of Covid-19 cases in a country, the number of Covid-19 tests performed, the number of available intensive-care beds et cetera. To ensure the supply of all interested parties with real-time data, countries launched their own Covid-19 dashboards. They enable international comparison, improve data quality and transparency, empower public opinion building in trusted sources and support risk informed decision making [29]. Thus Covid dashboards present a powerful tool for the public as well as governments to conquer a global crisis like Covid-19. That is why, in our thesis, we want to research the content of Covid-19 dashboards by answering the following two research questions:

What data is made available via European Covid-19 Dashboards?
Europe is a continent of many different countries, each with different rules and regulations. Nevertheless, most countries have decided to make their Covid-19 data available to the public via an official national dashboard. Our thesis will document and analyse the Covid related data of 26 European countries provided on their official Covid-19 dashboards. By creating a structured dataset of the aforementioned data, we make country dashboards comparable and provide insight into the most commonly used Covid-19 indicators and their granularity.

How have European Covid-19 dashboards evolved over time?
After more than a year of the Covid-19 pandemic, most countries report a variety of indicators on their dashboards. Of course, most of these indicators were not to be found there since the beginning of the pandemic, but have

been added over time. Therefore, our thesis also investigates the point in time at which the indicators were added to the dashboards. By documenting when an indicator was added to a dashboard, we can compare the usage of indicators over time and create individual country timelines to see, at what point in the pandemic the countries adapted their dashboards.

Regarding the previous work in the field of Covid-19 dashboards, a paper by Ivankovic et al [29] comes closest to the topic of our thesis. The paper analyzes the content of 158 public web-based Covid-19 dashboard. Even though the geological location of the analyzed dashboards is skewed towards European countries, the paper does not have a geological limitation to its research. In addition, the paper mainly analyzes the percentage occurrence of various indicators in the dashboards and does not conduct a country comparison. Neither does it look a the evolution of the dashboards over time. Nevertheless our thesis builds on the panel created by Ivankovic et al. for our own documenting of the dashboard content.

2 Literature Review

This chapter concludes the theoretical part of the thesis and deals with the historical development of Covid-19 as well as a short definition of dashboards and an explanation of their relevancy. To examine the overall history of Covid-19, we looked at different sources consisting of scientific papers, news articles as well as reports provided by official organisations like the World Health Organisation (WHO). By combining the information of the different sources, we can create a comprehensive Covid-19 timeline that summarizes all the most important actions of the organizations and the countries.

2.1 COVID-19 Pandemic

In December of 2020 the WHO China Country Office was informed about a case cluster of pneumonia of unknown cause detected in Wuhan City [36]. This case cluster is later going to be revealed as the first outbreak of Covid-19, a new coronavirus disease caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). This event marks the start of the to date ongoing Covid-19 pandemic. This chapter provides a timeline of the pandemic with key events based on various literature sources and articles as well as the documentation of the World Health Organization (WHO).

2.1.1 January – March 2020

After finding out about the new threat, the WHO published a comprehensive package of guidance documents for countries, related to managing the outbreak of a new disease. This included information about prevention and control measures, laboratory testing, travel advices as well as monitoring and management indicators [39]. With drastically rising cases in China as well as first cases in the United States and Europe the WHO declared the novel coronavirus outbreak a public health emergency of international concern on January 30th [38]. This caused the United States to restricting travel from China [48].

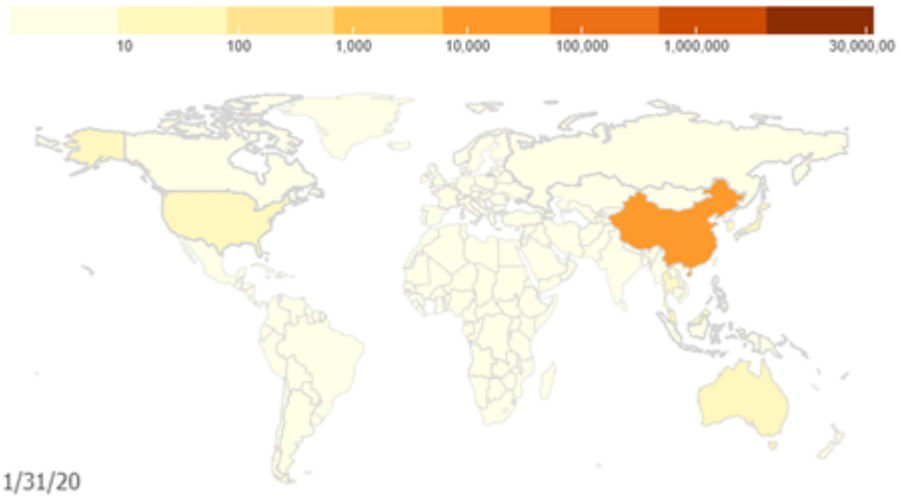

Figure 1: Cumulative Infection Numbers January 2020 [34]

In February the disease caused by the new coronavirus was officially named Covid-19 and Europe as well as the United States started reporting their first deaths caused by the new disease. The first major European outbreak of the pandemic was situated in Italy, where cases were increasing drastically from two to 1128 within a month. This resulted in Italy canceling their planned sporting and cultural events and closing their schools [48].
On the 11th of March, the WHO declared the spread of Covid-19 a pandemic [37]. Many countries seemed to realize the threat related to Covid-19 and imposed restrictions to slow the spread. The American Centers for Disease Control and Prevention advised people to not hold gatherings with more than 50 participants and New York announced to close their public school system. Europe also coordinated its first response by banning unnecessary travel to 26 European countries [48] while some countries, such as Austria,

individually start canceling events and closing shops [1].

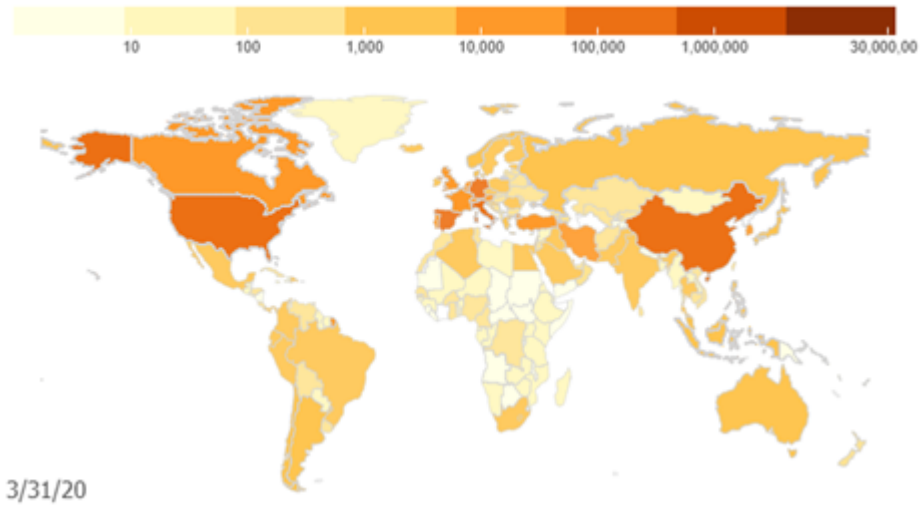

Figure 2: Cumulative Infection Numbers March 2020 [34]

2.1.2 April – June 2020

At the start of April, the worldwide number of Covid-19 Cases reached one million and the danger of an overload of the health care systems became more and more probable [48]. On top of that the amount of Covid-19 deaths started to rise drastically, as can be seen in figure 3. The goal was to 'flatten the curve', which meant to change, the previously exponential increase in new Covid-19 cases per day, to a more linear growth rate [6]. Most governments responded with the implementation of non-pharmaceutical interventions (NPIs) consisting of different public health and social measures to prevent the spread of Covid-19 and reduce its burden on the health system. Most NPIS, which are suitable to counter a virus like the Coronavirus, are severely restrictive and cause enormous economic and social costs [15]. Therefore, the unemployment rate in Europe and America increased drastically and major economies such as Germany and Japan fell into a recession [48] [33] [16]. At the end of April, the daily new infections were still high with a worldwide amount of round about 180.000 new cases per day, but the overall growth seemed to be more linear than before, as can be seen in figure 4. Thus, countries started to discuss reopening their economies and their borders, despite the WHO warning about the risks related to this behavior [17] [48].

Figure 3: 7-day moving average of Covid-19 Deaths (World) [21]

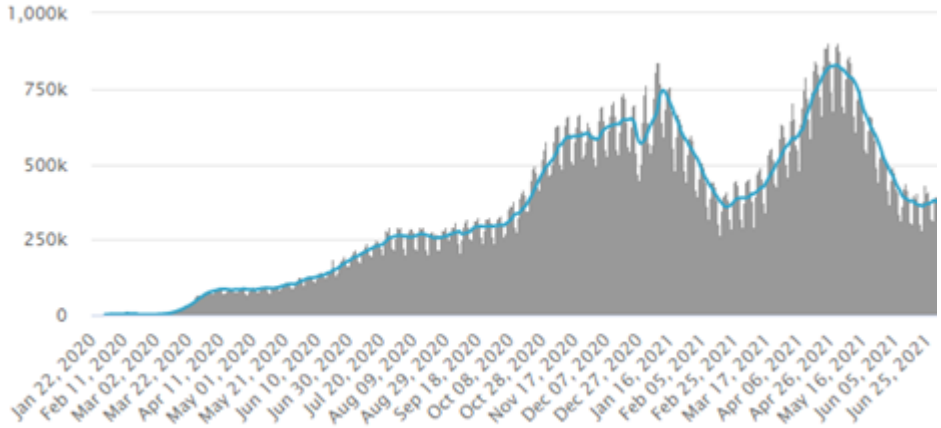

Figure 4: Daily New Cases + 7-day moving average (World) [51]

2.1.3 July – December 2020

What followed was an uncoordinated procedure of different countries simultaneously increasing and decreasing their Covid-19 measures. This started with the European Union reopening their borders to visitors from fifteen different countries [48]. During the EU's opening steps, some member states had already lifted numerous Covid-19 restrictions. In Austria, for example, the requirement to wear a mask in stores was suspended for about a month,

and bars and restaurants were allowed to open again [44] [22]. It is important to note that these relaxations occurred at a time when other countries such as Iran, Hong Kong and the United States experienced an extreme increase in cases and deaths leading to further lockdowns and closures [48]. Figure 4 shows, that this uncoordinated approach led to a steady increase in daily new infections, which reached their first peak in the period from December 2020 to January 2021, with average daily global new infections of around 700,000.
On November 9th, Biontech and Pfizer reported, that their new Covid-19 vaccine showed a 90 % effectiveness in protecting people from transmission [9]. Both Biontech and Pfizer are large pharmaceutical companies, the former headquartered in Germany and the latter in the United States. For the full effectiveness of the vaccine, two doses must be administered, and the vaccine must also be stored regularly at -70 degrees celsius [23]. These circumstances require countries to have a well-thought-out vaccination strategy. On December 2nd the United Kingdom became the first ever country to permit Biontech/Pfizers new Covid-19 Vaccine [31]. On December 18, a second Covid-19 vaccine from the American biotechnology company Moderna was first approved in the United States [41]. Moderna was followed by a third vaccine from Oxford University called 'AstraZeneca' which was first approved by the United Kingdom on December 30th [32]. So far, all vaccines required two doses to be administered for a sufficient protection against the virus.

2.1.4 January – June 2021

On February 27th, 2021, the United States licensed the first 'one–shot' Covid-19 vaccine called 'Johnson & Johnson'. The vaccine was developed by the Dutch biopharmaceutical technology company Janssen Vaccines and provided 85 percent efficacy after a first dose [40]. To sum it up, starting into 2021 there were four different vaccines available, and the overall demand was high. And since the United States and the United Kingdom were the first to approve these vaccines, they were able to build up a certain lead over the EU in the first three months of 2021. This can be seen in figure 5. During March, rumors emerged that the AstraZeneca vaccine was causing increased thrombosis. This led some countries, including Austria, Denmark and Norway to discontinue the vaccine completely or to pause vaccinations with it. On March 20th the WHO released a report, stating that there was no connection between thromboses and the AstraZeneca Vaccine. Even though many countries resumed using the vaccine after the statement, it is to assume that this greatly damaged the vaccination readiness of a lot of people [14].

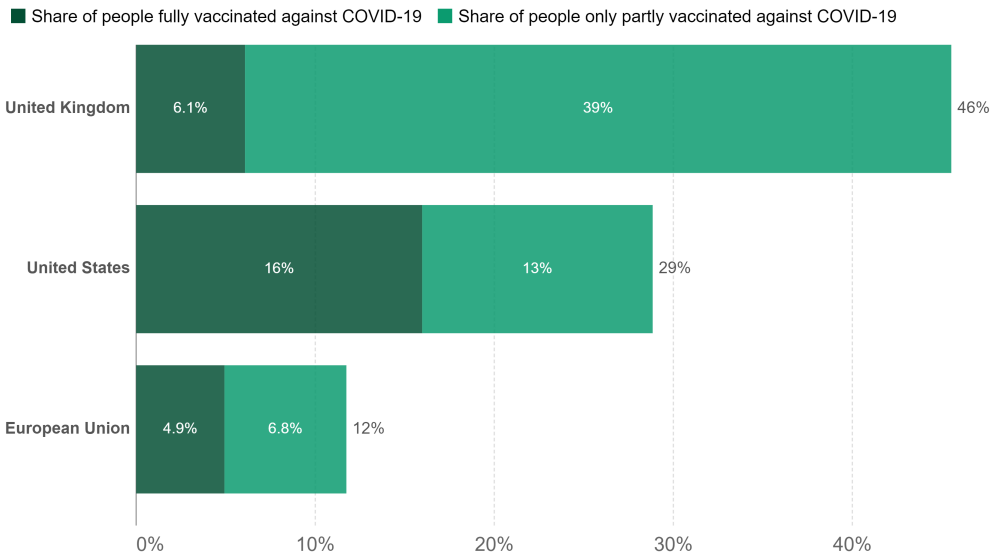

Figure 5: Share of People vaccinated against COVID-19 March 2021 [45]

Following the vaccination rumors, India got hit by another infection wave, during which the so-called 'delta variant' first started to spread in a large scale. The delta variant is a specific mutation of the Coronavirus whose first traces can be found in late 2020. Even though this was not the first mutation of the virus (Beta and Gamma-Variants already existed) it was highly in discussion because it seemed to be 60 percent more transmissible than its predecessor [12] [35].
At the end of June 2021, the daily new infections were relatively low again, which may be due to many countries imposing lockdowns in the previous months. Looking at figure 6 we can also see that the EU managed to catch up in vaccination numbers compared to the US and the UK. From this point on it will be interesting to see, how many people are willing to get the vaccines and how the vaccines will impact the upcoming infection waves after the imposed lockdowns are lifted again.
The observed period taken into consideration for this thesis' research ends with Summer 2021. That is we did not take into consideration the - particularly in Austria - 4th wave of corona infections as well as discussion about further booster vaccines or legal enforcements of vaccine obligations currently ongoing (Status: Nov 2021).

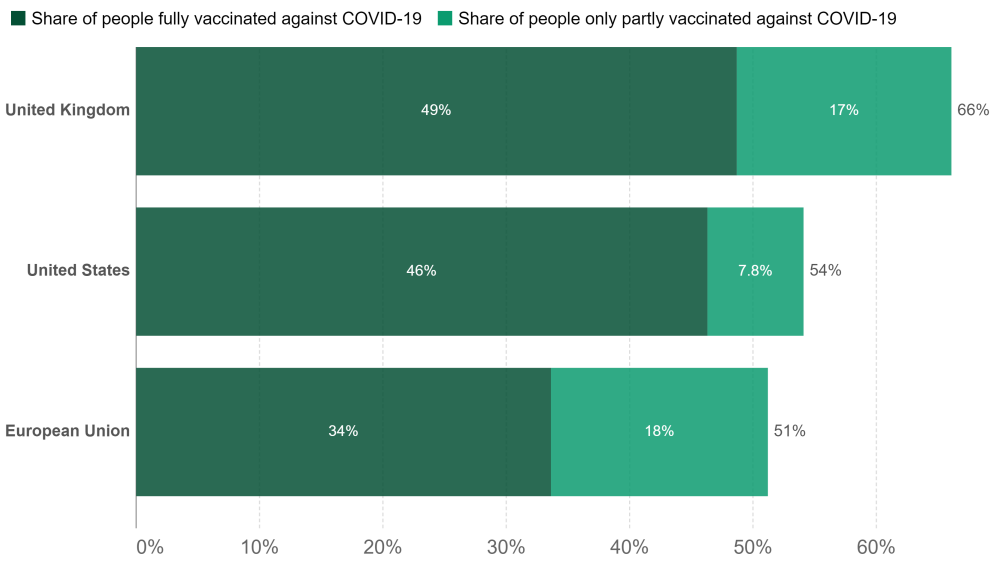

Figure 6: Share of People vaccinated against COVID-19 June 2021 [45]

2.2 Dashboards

Dashboards are currently on of the most used tools for data visualization. They are built and employed by nearly every type of organization, be it industry, non-profit or services organisations to support data driven decision making [46]. Wexler et. al defines a dashboard as follows:

> ... a visual display of data used to monitor conditions and/or facilitate understanding [49].

Basically, the term 'dashboard' is used very broadly to describe the most diverse applications of data visualization. Its basic concept of a single view reporting screens, has over time evolved into including interactive interfaces and multiple views often times providing features of communication, learning and motivation next to the more basic features of monitoring and decision support [46].

At the start of 2020 the worldwide demand for Covid-19 data was high and unlike static reports, dashboard allowed for near-real-time situation updates. This convenience, combine with the trend of digitizing healthcare systems, and the overall availability of open-source web-based software made public web based dashboards a widely used reporting tool for Covid-19 data [29].

3 Methods

In this chapter, we will explain our approach to documenting the Covid-19 dashboards step by step. We ended up reviewing the dashboards of 26 European countries. Our goal was to document the type of information displayed on the official government dashboards as well as the point in time at which the information was added, thus giving us a sense of overall development of the dashboard. Each dashboard was reviewed in the original language using google translator. To collect the information, we made use of a python script trying to detect website changes as well as the online tool 'Wayback Machine'.

3.1 Panel Creation

Our first goal was to design a panel according to which we could document the dashboards. As an orientation we used a very current paper which dealt with exploring the characteristics of public web-based Covid-19 dashboards [29]. The paper looked at a variety of dashboards from different organizations providing all kinds of information. Based on the panels used by this paper, we created our own panels by adopting the criteria covered in their panels for our own panels. We ended up with two different panels, one for vaccination and one for case dashboards which can be seen in figure 7.
The 'Level' component of the panels is the same for both the case dashboards and the vaccination dashboards. A dashboard was considered to report a certain level of data if at least one of the main indicators (Public health and epidemiological numbers, Testing, Health system management, Vaccination numbers) was reported in that granularity. Same goes for the 'Presentation' component.
Also, the 'Languages Available' component was the same for both dashboard types. As long as a dashboard provided one of the main indicators (Public health and epidemiological numbers, Testing, Health system management, Vaccination numbers) in another language than its original one it was considered to support multiple languages.
A more detailed explanation of each indicator can be found in section 4, as we discuss every indicator used in the dashboard.

Cases	Vaccines
Level (0.5 Points)	**Level (0.5 Points)**
National	National
Regional (provincial, state, county)	Regional (provincial, state, county)
Municipal (city, district)	Municipal (city, district)
Age	Age
Sex	Sex
Jobs (Health workers)	Jobs (Health workers)
Languages available (0.5 Points)	**Languages available (0.5 Points)**
One language	One language
Two languages	Two languages
Three or more languages	Three or more languages
Public health and epidemiological numbers (1 Point)	**Vaccination numbers (1 Point)**
Cases	Doses administered
Deaths	First and second doses administered
Recovered (healed, cured)	Types of doses administered
in quarantine	Doses ordered
Active cases	Types of doses ordered
Mortality rate (case fatality rate)	Doses in stock
R	Types of doses in stock
Incidence	Doses received
Testing (1 Point)	Types of doses received
Total number tested	Vaccination rate
Type of tests used	Vaccination rate (first/second shot)
Testing rate (positivity, negative tests)	**Risk Management (0.5 Points)**
Health system management (1 Point)	Vaccination strategy
Hospitalized (admissions, discharges)	Side effects
Admitted to ICUc (critical condition)	Vaccination registration
Pre existing diseases	**Presentation (0.5 Points)**
On a ventilator	Time trend analysis
Hospital bed capacity (availability)	by day
ICU bed capacity	by week
Ventilator capacity (available ventilators)	by month
Personal protective equipment stock	Graphs/Charts
Testing stock	Maps
Presentation (0.5 Points)	Tables
Time trend analysis	**Data (0.5 Points)**
by day	Downloadable Dataset
by week	Scrapable Data
by month	
Graphs/Charts	
Maps	
Tables	
Data (0.5 Points)	
Downloadable Dataset	
Scrapable Data	

Figure 7: Panel

3.2 Dashboards

In order to find the official Covid-19 dashboards of the governments, we oriented ourselves to the ministries of health of the different countries. The Geneva Foundation for Medical Education and Research provides a website which collects the links to the official websites of the ministries of health for 195 countries [20]. For each one of the 26 countries, we searched for a Covid dashboard on the ministry's website. During this step, we found a case dashboard for the majority of the countries. But some of the case dashboards as well as most of the vaccination dashboards were still missing. Our second approach was to check the website of the European Centre for Disease Prevention and Control (ECDC) [19]. In their vaccine rollout overview, they listed the national references of the data they use for their report. After checking the sources of the ECDC, we ended up with the official vaccination dashboards for 25 countries and the official cases dashboard for 26 countries. Since some of the dashboards were spread among multiple URLs, some countries ended up with multiple dashboard entries. Earlier versions of the dashboards that were available via another link, which was neither on the website of the respective Ministry of Social Affairs nor stated on the ECDC reports, are not included in the evaluation. The entire list can be seen in the sources spreadsheet of [24].

3.3 Wayback Machine

The Wayback Machine is a digital archive of the World Wide Web founded by the nonprofit library 'Internet Archive'. It collects its data using a variety of crawlers provided by different organisations, with Alexa Intranet, a subsidiary company of Amazon, being the major source [30]. A crawler or web crawler is a program designed to retrieve web contents and insert them to local repository [43]. The service allows people to visit archived versions of web sites by typing in a URL and selecting a date range.
We used the Wayback Machine to investigate when dashboards added the informations covered in figure 7. We did that on a monthly basis, so for example information added on the 16th of June 2020 got documented as '06.2020'. Since the Wayback Machine struggles with storing dynamic pages that contain forms, JavaScript or other elements that require interaction with the originating host, a time series documentation was not possible for every dashboard in the list. If the Wayback Machine was not able to reconstruct a dashboard, we would look at the original and up to date version of the dashboard and documented any information found there with a 'x' instead of the 'mm.yyyy' notation mentioned before. We decided to only review dash-

boards until the 31st of June, so any information added to the dashboards after this date is not included in our documentation.

3.4 Python Script

To simplify the documentation of the dashboards using the various snapshots in the wayback machine we have developed a simple python code that highlights changes on the website based on the source text size. The python script uses the plugin 'waybackpack' to communicate with the Wayback Machine. The plugin allows you to download the entire Wayback Machine archive for a given URL [47]. We used 'waybackpack' to add all the archived URLs of our dashboards to country specific lists. Since most dashboards had archived several hundred versions and an evaluation of these would have clearly taken too long with the given computing power, we shortened each country-specific list to about 20 entries. This was done using a loop which always deleted the fourth element in the list until there were less than 20 elements left in it.
Our function, to determine the size of the source text, used the 'beautifulsoup' and the 'request' package to save the html code of each archived snapshot to a local .txt file. The function then deleted all unnecessary information contained in the actual URL of the website to end up with just the date of the archived snapshot. Both the date of the snapshot as well as the size of the snapshot were saved to two different variables and then printed out in the following style: [26] [1]

File Size is : 27133 bytes on 20200606
File Size is : 27132 bytes on 20200606
File Size is : 27137 bytes on 20200607
File Size is : 28811 bytes on 20200709
File Size is : 28725 bytes on 20200726
File Size is : 28861 bytes on 20200817
File Size is : 28881 bytes on 20200917
.
.

[1] for Austria's national dashboard accessible under the URL `https://info.gesundheitsministerium.at/`. A particular snapshot for such a page at the Internet Archive's wayback machine can be acessed under URLs that encode the available timestamp, e.g. `https://web.archive.org/web/20210915000000*/https://info.gesundheitsministerium.at/`

We then looked at the snapshots of each month in which major jumps in the file size occurred. If no big jumps in the website size were noticeable, we started looking at the latest available version in each month. But most of the time the problem was related to the Wayback Machine having problems with dynamic content which, as mentioned earlier, meant that we had to skip the temporal documentation for this website. The documentation itself was done manually in Microsoft Excel. The results can be seen in the Cases and Vaccines Spreadsheets in [24].

4 Dashoboard Indicators

The goal of this chapter is to explain the indicators used for our two dashboard panels first shown in figure 7. We will dig into the meaning of each indicator as well as the prerequisites a dashboard had to provide in order to be documented as containing that indicator. Since some of the indicators are used in both the cases panel as well as the vaccine panel we will describe those indicators once for both dashboards.

4.1 Level

The level section is supposed to document the type of granularity in which the data is displayed on the dashboards. It was documented that a dashboard provided a certain granularity if at least one of the indicators from the sections 'Public health and epidemiological numbers', 'Testing', or, for the vaccines dashboard, 'Vaccination numbers' were reported in the respective granularity. So for example, if a case dashboard distinguished between age in their reported cases, but not in their reported deaths, they still were documented to provide the 'Age' level of granularity. This simplification also applies to the 'Presentation' and 'Languages available' sections for both dashboard types and was made to not extend the workload of the semi-automatic documentation of the dashboards.
The geographical granularity was determined by three indicators. A dashboard was considered to report national data if it provided cumulative figures for the whole country. A regional level means, that the countries report figures separately for Provinces, states or counties and a municipal level dashboard provides separate figures for cities or even districts.
The 'Age' indicator documents if a country distinguished between age or age groups in their reported figures. This indicator is especially interesting because it can be seen as a direct link to the amount of available intensive care beds in a country. Since older people are expected to suffer a more serious

course of disease, a high number of new cases in an older age group can be alarming.
The 'Sex' indicator documents if a country differentiates between male and female in their reported figures. For this indicator a country did not have to provide more than those two distinctions.
The 'Jobs' indicator is probably one of the most unique indicator on the dashboards. It documents if a dashboard provides some sort of figures specifically for certain job groups. Since the workplace is a place with serious risk of infection we expected to see some countries provide figures like the number of cases for healthcare workers, teachers or other system-relevant workers [42].

4.2 Languages available

The 'Languages available' section provides information about the amount of languages a dashboard provides. Providing different languages can be crucial to ensure, that the majority of people living in a country can interpret the dashboards correctly. Often times the governments provided only a simplified version of their original dashboard in a different language, which is why the simplification described in the previous subsection is also applicable for these indicators.

4.3 Public health and epidemiological numbers

This is a section exclusive to the cases panel and covers a list of infection indicators that are important to overlook during a pandemic.
The case indicator is the most central indicator of the whole cases panel and documents if a country reports the number of people tested positive for the coronavirus. The data on the new cases can be cumulative in different ways. However, the most common presentation is with daily new infections. Some of the indicators in the same section are very similar to the case indicator and therefore can be understood as a more detailed way of reporting simple cases. 'Recovered (healed, cured)' for example shows the amount of people that have survived a Covid-19 infection. This indicator is interesting to track because it can be linked to the level of herd immunity (percentage of people with antibodies) in a country[50]. 'Active Cases' is the quiet opposite way of displaying the cases by listing the amount of patients that have not yet been cured and are still alive. The most unique way of displaying the active cases is probably by listing the number of people that are currently in quarantine, due to being infected or being closely related to an infected person.
The indicators 'R' and 'Incidence' provide a more interesting way of looking at the overall spread of the virus. The 'R' or reproduction number of a

pandemic is the number of people that one infected person will pass on a virus to. For example an R of 15 means, that one infected person on average passes on the virus to 15 persons. Therefore an 'R' greater than one leads to exponential growth in [8]. The 'Incidence' provides a way to report new cases in a comparable way by adjusting the figures by their daily fluctuation and the population of the country. For example a seven-day incidence per 100,000 population shows the cumulative number of new cases from the last seven days, divided by one hundred thousandth of the respective population. A way more controversial indicator is the one for deaths. It is generally known, that counting Covid deaths can be complicated because of numerous reasons [10]. Nevertheless, we documented the indicator for all countries that reported a death count on their dashboard, regardless of the counting method. Mortality rate provides just another representation of the death and case counter by dividing cases by deaths.

4.4 Testing

Compared to the other two case panel specific sections, the testing section is rather short but not at all less important. To tell if a person has Covid-19 you have to perform a Covid-19 test. Apart from the antibody test, which tells you if you already had Covid 19 in the past, there are two prominent tests that are used to determine if a person is currently infected with the Coronavirus. The RT-PCR test, which provides a result within a few days and the antigen test, which provides a result within a few minutes but with less accuracy [11]. To determine how valid the current number of new cases are it can be helpful to look, not only at the number of tests performed, but also at the types of tests used [13]. The indicator 'Type of tests used' is once again only a more detailed version of the 'Total number tested' indicator. The 'Testing rate' allows for a quick comparison of new cases and tests performed by dividing positive tests by total tests.

4.5 Health system management

As already mentioned in Chapter two, the main reasons for the governmental restrictions during the Covid-19 pandemic were to prevent the overload of the healthcare system. The indicators listed in this section can be used to spot upcoming bottlenecks related to hospital capacity and equipment stock. The two indicators 'Hospitalized' and 'Admitted to Intensive Care Unit' show, how many Covid patients are currently treated at a hospital and give an indication of how common a severe course of the disease is. The current usage of ventilators for Covid patients provides a similar information.

Information about preexisting diseases of the hospitalized Covid patients can be interesting to, since it can motivate people with those diseases to take more care. All the other capacity and stock indicators of the section are just extensions of the other indicators, by adding the information of availability. In combination, those indicators provide an important tool for decision making in the pandemic.

4.6 Vaccination Numbers

This vaccine panel specific section includes not only information about the progress in the vaccination process, but also about the vaccination capacities. As already mentioned in chapter two, there are multiple Covid-19 vaccine types from different vaccine manufacturer, most of them require two shots for their full effectiveness. Our first three 'administered' indicators try to implement these levels of information into indicators. 'Doses administered' just shows the sum of all the doses administered, either in total or for a certain time period. This information can be complimented by specifying if the administered doses were first or second shots and by specifying the the type of vaccine used. To display the availability of the vaccines in a country the panel provides three different indicators, each with and without the more detailed level of the type of vaccine. 'Doses ordered' just shows the amount of doses a country ordered and does not provide information about already arrived doses or about doses that are still going to arrive. 'Doses received' specifies this information a little bit more by stating all the doses that already got delivered, but it still fails to provide information about the currently available doses. 'Doses in stock' is the most detailed version of the two indicators listed before. It describes the amount of doses that are currently available for vaccinations. Last but not least the vaccination rate is probably the best way of displaying the vaccination progress in a country as it divides the amount of people with a vaccine by the (vaccinable) population of a country. Once again we added a second indicator that specifies if the vaccination rate distinguishes between first and second shot.

4.7 Risk Management

The Risk Management section can be understood as kind of a special section containing supplementary information about the vaccine. Again as already mentioned in chapter two, the Covid-19 vaccine was and is still linked to a fair amount of rumours, therefore it can be helpful to provide educational information on ones dashboard. The vaccination strategy, for example, states the different stages of the vaccination process, including information about

the date at which certain age and job groups can expect to get a chance to receive their vaccines. Of course adding educational information about possible side effects also accounts towards the overall transparency. And since it is to assume that people who check a vaccination dashboard are also interested in getting a vaccine, a direct link to a registration page can speed up the overall process of getting people vaccinated.

4.8 Presentation

This section is once again shared by both panel types and provides indicators, describing the way, the data is displayed on the dashboard. The first four indicators belong together, as they cover, if a dashboard provides some sort of time trend analyses by day, week or month. Everything on the dashboard that provides a figure for multiple dates in a row was considered to be a 'Time trend analysis'. So for a dashboard to include the first four indicators, it didn't matter if the time series was displayed in a table, a line chart or even a map. Those specifications were documented with the last three indicators of this section. 'Graphs/Charts' covers any form of visual data presentation in the form of line charts, bar plots, pie charts, boxplots, and so on and so forth. If a country used (interactive) maps to present their data, it was documented via the 'Maps' indicator regardless of the level of detail of the map (National, Regional, Municipal). Another way of presenting data is via a simple table. Even though this is not the most creative way of presenting different indicators, it can be a very informative one. In our documentation a country provided a table if it presented information structured by rows and columns.

4.9 Data

This is the last section of both dashboard panels and it covers the overall accessibility of the data. Looking at our panels we can see that we have implemented two different indicators to determine if and how the data is made accessible. The indicator 'Downloadable Dataset' describes if the dashboards provide a link that leads to official and downloadable Covid related data sets. Our second indicator 'Scrapable Data' basically checks if the indicators provided on the dashboard are accessible through the snapshot of the website that was stored in the 'Wayback archive' mentioned in Chapter 3.3. If this is the case, it is possible for an individual to access the source code of the snapshot and extract the information provided on the dashboard, making the data accessible again, even though this is not as convenient as a link to a downloadable data set.

5 Dashboard Analysis

This chapter contains the analysis of the dataset created in chapter 3. We will first create a country ranking to see, which countries appear to be the most transparent in reporting their Covid data. Afterwards, we will take a closer look at the individual indicators to find out which ones are most frequently found on the dashboards and in which chronological order they were added, thus giving us a sense of the overall development of the dashboards. To check for a certain pattern in the dashboard adaptation, we created timelines including the dates of 'key events' in the pandemic as well as the dates of the dashboard adaptations to check for a connection between the two. Finally, in this chapter we will also take a look at 'special' indicators that are only published by a very low number of dashboards, thus making them unique. Again it is important to mention here, that these evaluations are solely based on the data provided by the countries through their official government dashboards, and do not include indicators published by other open datasets or news companies. All calculations in this chapter were either done with Microsoft Excel [24] or R [25]. By downloading the .zip files in the attachments, one can fully recreate our analysis.

5.1 Indicators

We now want to focus on analysing the different indicators used in our dashboard panels. We will start by analysing the frequency in which the indicators can be found on the dashboards. We do that to find out which of the indicators of our panel are rather common on a dashboard, and which ones are rare. We will then go on and look at the time aspect of each indicator. This way we can analyse which indicators were added in a very early stage of the pandemic and which indicators were added later on. In summary, our panel comprises 70 indicators, 38 of which are for case dashboards and 32 for vaccine dashboards. The summarised results for all the different indicators can be seen in Table 1 and 2.

5.1.1 Frequency

To analyse the frequency of each dashboard indicator, we first counted the number of entries for each row form [24] and then divided that number by the total number of countries for each dashboard type. For the case dashboard we divided by 26 and for the vaccine dashboards we divided by 24, because as already mentioned before, we were not able to find an official vaccine dashboard for Malta and Liechtenstein only provided a download link

Level	Frequency	Median	Min	Max
National	100%	4,4	2	9
Regional (provincial, state, county)	85%	4,4	2	9
Municipal (city, district)	42%	5,9	2	11
Age	65%	5,5	2	9
Sex	50%	5,0	2	9
Jobs (Health workers)	12%	6,0	5	8
Languages available				
One language	100%	5,3	2	14
Two languages	19%	6,8	2	14
Three or more languages	4%			
Public health and epi...				
Cases	100%	4,6	2	9
Deaths	88%	4,9	2	14
Recovered (healed, cured)	62%	4,5	2	9
in quarantine	8%	3,0	3	3
Active cases	42%	6,2	3	9
Mortality rate (case fatality rate)	0%			
R	15%	7,5	6	9
Incidence	46%	10,6	6	17
Testing				
Total number tested	69%	5,4	2	9
Type of tests used	31%	8,3	4	12
Testing rate (positivity, negative tests)	58%	6,2	2	14
Health system management				
Hospitalized (admissions, discharges)	62%	6,3	2	9
Admitted to ICUc (critical condition)	65%	5,6	2	9
Pre existing diseases	8%			
On a ventilator	19%	6,0	6	6
Hospital bed capacity (availability)	15%	8,3	6	10
ICU bed capacity	12%	9,5	9	10
Ventilator capacity (available ventilators)	4%	10,0	10	10
Personal protective equipment stock	4%	2,0	2	2
Testing stock	4%			
Presentation				
Time trend analysis	92%	5,0	2	9
by day	92%	5,0	2	9
by week	4%			
by month	0%			
Graphs/Charts	96%	5,1	2	9
Maps	81%	4,6	2	9
Tables	54%	4,3	2	9
Data				
Downloadable Dataset	38%	6,8	2	11
Scrapable Data	65%	5,6	2	17

Table 1: Case Dashboard Results

Level	**Frequency**	**Median**	**Min**	**Max**
National	100%	12,6	12	16
Regional (provincial, state, county)	58%	12,2	12	13
Municipal (city, district)	46%	12,7	12	14
Age	58%	12,4	12	13
Sex	46%	12,3	12	13
Jobs (Health workers)	17%	12,0	12	12
Languages available				
One language	100%	12,4	11	16
Two languages	33%	12,8	11	17
Three or more languages	17%	14,0	11	17
Vaccination numbers				
Doses administered	100%	12,6	12	16
First and second doses administered	92%	13,2	12	17
Types of doses administered	46%	13,7	12	16
Doses ordered	13%	12,0	12	12
Types of doses ordered	8%	12,5	12	13
Doses in stock	13%	14,0	13	15
Types of doses in stock	8%	14,0	13	15
Doses received	25%	13,0	12	15
Types of doses received	17%	13,3	12	15
Vaccination rate	46%	14,4	12	17
Vaccination rate (first/second shot)	29%	14,7	13	17
Risk Management				
Vaccination strategy	21%	12,4	11	13
Side effects	13%	13,5	11	16
Vaccination registration	17%	13,3	11	16
Presentation				
Time trend analysis	71%	13,6	12	16
by day	54%	13,8	12	16
by week	33%	13,3	12	16
by month	0%			
Graphs/Charts	71%	13,2	12	16
Maps	50%	12,4	12	13
Tables	38%	12,0	12	12
Data				
Downloadable Dataset	50%	13,0	12	17
Scrapable Data	58%	12,8	12	16

Table 2: Vaccine Dashboard Results

to a dataset. The calculations for both dashboard types were made with Microsoft Excel [24].

We are first going to take a look at the results for the case dashboards. In the level section we can see that the most frequently used granularity next to national was regional(85 percent). Furthermore, less than 50 percent of the countries reported on a municipal level. About half of the countries also diversified between age and sex in at least one of their figures. The least frequent Level indicator was, as expected, 'Jobs' which was only reported by three countries.
The results of the level section are also quiet interesting. Only 19 percent of the countries provided a second language for their dashbaord.
In the 'Public health and epidemiological numbers' section, it comes to no surprise that 'Cases' is the most frequently used indicator, closely followed by the number of deaths. Round about 50 percent of the counties also reported the number of recovered Covid-19 patients, active cases and some variation of incidence. To our surprise the 'R' indicator was only found in 15 percent of the dashboards, despite it being an often mentioned indicator in Covid-19 related news. Furthermore, only 2 dashboards reported the number of people in quarantine.A specifically reported mortality rate was not reported by any of the countries on their dashboards.
Providing figures related to Covid-19 testing was also not the custom on the dashboards. Only round about 70 percent reported the total number of tested people and 60 percent reported a related test rate. The types of tests used were only stated in 30 percent of the dashboards.
For the 'Health system management' section the most popular indicator was the number of patients admitted to ICU (65 percent), closely followed by the amount of patients hospitalized (62 percent), round about 20 percent also mentioned if a patient was on a ventilator. Only a few more than 10 percent reported their hospital and ICU bed capacity and even less reported their currently available protective equipment, tests and ventilators.
Regarding the presentation of the data 96 percent of the countries went with some sort of graphs or charts, 81 percent provided a map and 54 percent went with tradition tables. A daily time trend analysis was also common among the dashboards with round about 90 percent of the dashboards providing one.

Next we are going to look at the indicators of the vaccine dashboards.
The frequency results of the level section from the vaccines panel are very similar to the ones from the cases panel. The only major difference is the frequency of the regional indicator. It seems like only about 60 percent of all countries reported data in regional granularity. This is 20 percent less

than in the cases dashboards. It is also interesting to note that one more dashboard included the 'Jobs' indicator.
The results of the languages sections also indicates that the vaccine dashboards seem to bee more 'international'. 33 percent of the countries decided to include a second language and 17 percent decided to add three or even more.
Of course the most reported indicator from the vaccines panel was the 'Doses administered' indicator closely followed by the distinction into first and second shot (92 percent). The second most frequently used indicators in the same section are the 'Types of doses administered' and 'Vaccination rate' both with a frequency of 46 percent. A distinction between first and second shot in the vaccination rate was only made by 29 percent of all countries. Information about doses ordered and doses in stock were provided by 13 percent and only 8 percent mentioned the types of doses together with those indicators. Slightly more countries reported the amount of doses received (25 percent) and 17 percent indicated what types of doses were received.
The 'Risk Management' sections seemed to be the least prominent in the vaccines panel. Only 21 percent of the countries reported a vaccination strategy on their dashboard, 17 percent added a link to a vaccination registration, and only 13 percent included information about possible side effects of the vaccine.
If we compare the results of the 'Presentation' section from our vaccines panel to the one from our cases panel we can see, that the overall presentation is significantly less on the vaccine dashboards, although the overall preference for the different presentation methods stayed the same. Graphs and Charts are still the most prominent form of displaying the vaccination numbers (71 percent) followed by maps (50 percent) and tables (38 percent). The usage of time trend analysis also decreased compared to the case dashboards. 71 percent use a time trend analysis, but this time more countries went for a weekly interval.
In terms of data availability it is good to see that 50 percent of the countries provided a link to a downloadable data set.

5.1.2 Time

In the following section, we will look at the temporal component of the indicators. In order to be able to make a comparison of this type, we tried to calculate the average time at which the respective indicators first appeared on the dashboards. Our first step was to remove all entries from [24], which were not documented with a date, from our data set. This step reduced the entries in the cases panel from 445 to 272 and in the vaccines panel from 323

to 178. In the next step we calculated, for each entry left, the months past between the 1. January 2020 and the documented date. We then, for each indicator, calculated the average months past, as well as the lowest and highest value for each indicator. This way, a low value in the time column from table 1 and table 2 indicates that an indicator was added to the dashboard earlier and vice versa. The calculations were done using Microsoft Excel [24].

In the following analysis of which indicators were published earlier and which were published later, on the dashboards, we limit ourselves to all indicators where a timestamp was documented for at least 9 dashboards(35 percent), since the average value would otherwise be too dependent on individual dashboards.
According to our results, the earliest indicators found on the dashboards were national and regional tables showing the number of cases as well as recovered patients (4.4 - 4.6 Months). This was round about May 2020, so during the time where 'flatten the cure' was considered the main goal of the pandemic, and the first countries started to impose NPIs. What followed were the number of deaths as well as a better presentation in the form of graphs, timelines and maps. Also, a distinction between sexes was added(4.6 - 5.1 Months). In the next step, the distinction by age groups was added, and the number of tests performed was added.(5.4 -5.5) In the final steps the dashboards started to report, first all ICU patients and then all hospitalized patients. (5.6 - 6.3) Those additions were made in June and July of 2020, so during a time were most countries started to feel the negative effects of the NPIs and slowly started reopening their borders and lifting their restrictions. Obviously, the changes on the vaccine dashboards happened at a much later stage of the pandemic. The first numbers reported on the dashboards were national and regional numbers of the administered doses. (12.2 - 12.6 months) Most countries started to report those numbers in the middle of January 2021, so during a time where a major amount of countries have licensed at least one vaccine. Half a month later in February the countries started to report the distinction between first and second shot, which aligns with the time you need to wait between getting the two shots. This change also came with a better presentation of data using graphs and charts. In mid-February the countries also started to add a time trend analysis of the vaccination numbers. (13.6 -13.8 Months)

5.2 Time Trend

To investigate if there is a connection between key events in the pandemic and dashboard adaptations we created two different timelines for each country.

The first timeline will show the changes in the case dashbaoards along with the Covid-19 wave peaks of each country. Since there are no clear rules as to when a country is experiencing a wave and when it is not, we had to collect the data for this evaluation ourselves. We used the visualization tool of 'Our World in Data' [21] and looked at the daily new confirmed cases in a 7-day rolling average interval, relative to the population. We selected each country from our list in [24] and documented each month in which a peak of a wave was visible to the naked eye. Since this was less clear for some countries than for others, an example can be seen in figure 8 for Latvia, the red dots show the months we picked for each wave. If a country had a small bounce within the first 5 months (like in Latvia) we counted it as a wave peak, in later months the peak had to be much more visible for us to document it. All the documented dates of the waves can be found in [24] in the 'Events' spreadsheet.

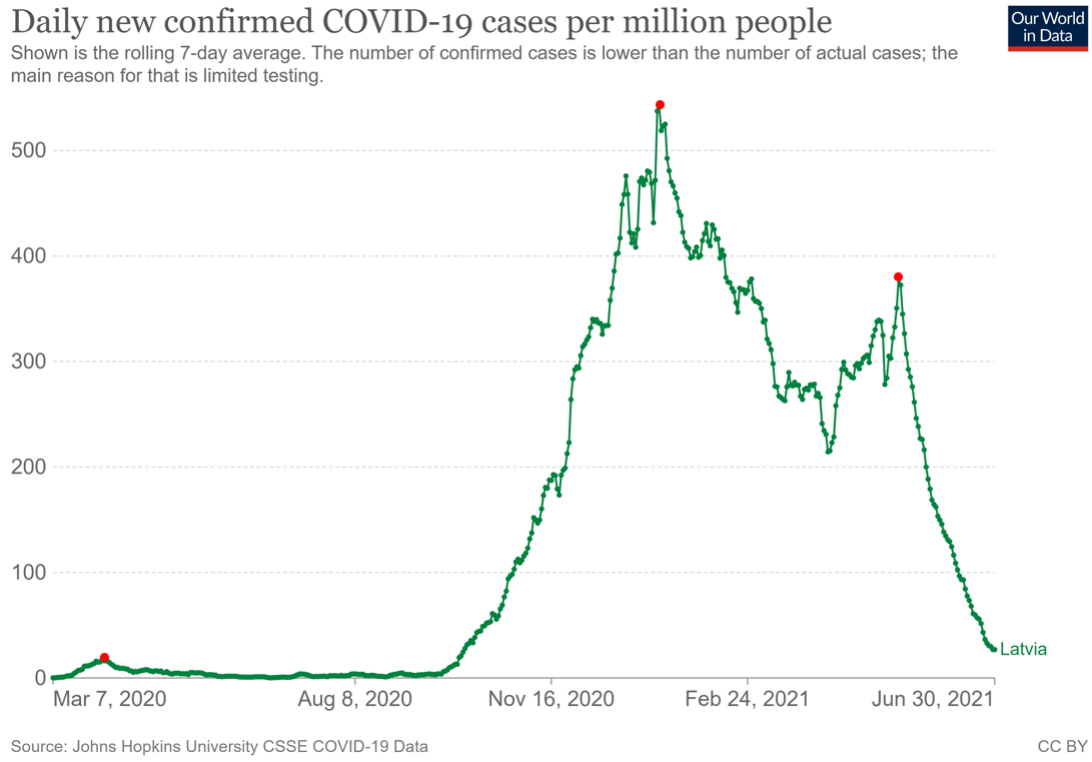

Figure 8: Latvia Cases [45]

The second timeline shows all the adaptations of the vaccine dashboards together with the date of the European vaccine approvals for the vaccines

from Biontech/Pfizer [2], Moderna [3], Johnson Johnsson [4] and AstraZeneca [5]. To create the timelines, we first got rid of all the entries from our panels, that were not documented with a date. We then manually applied the wave peak data to the case panel and the vaccine approval data to the vaccine panel. We then loaded the two datasets into R to create the timelines with the help of the timevis package. Timevis is a freely available package which allows you to create interactive timelines in the form of an html widget [7]. All of the timelines can be reproduced by running the R markdown file from [25]. A download for the screenshots of all the created timelines can be found in section A (Attachments).

5.2.1 Cases

When looking at the timelines for the case dashboard indicators, we can observe two different patterns. The "learner" pattern shows countries that, after the first wave, only added a few indicators or no indicators at all, but started to extend their dashboards during the build up of the second wave. An example of this pattern can be seen in figure 9 which shows the indicator timeline of Austria. The same patterns can also be observed when looking at the timelines of Denmark, Ireland, Luxembourg, and the Netherlands.
Our "pioneer" pattern shows countries that published most of their indicators around the time of the first wave. When the second wave arrived, they only published a few new indicators or no new indicators at all. Again an example can be seen in figure 10 which shows the timeline of Sweden. The same patterns can also be observed when looking at Croatia, Poland, Romania Norway, Slovenia, Bulgaria and France.
The two countries that do not fit into the two patterns mentioned before are Spain and Latvia. Both countries added the indicators to their dashboard a few months after the first wave.

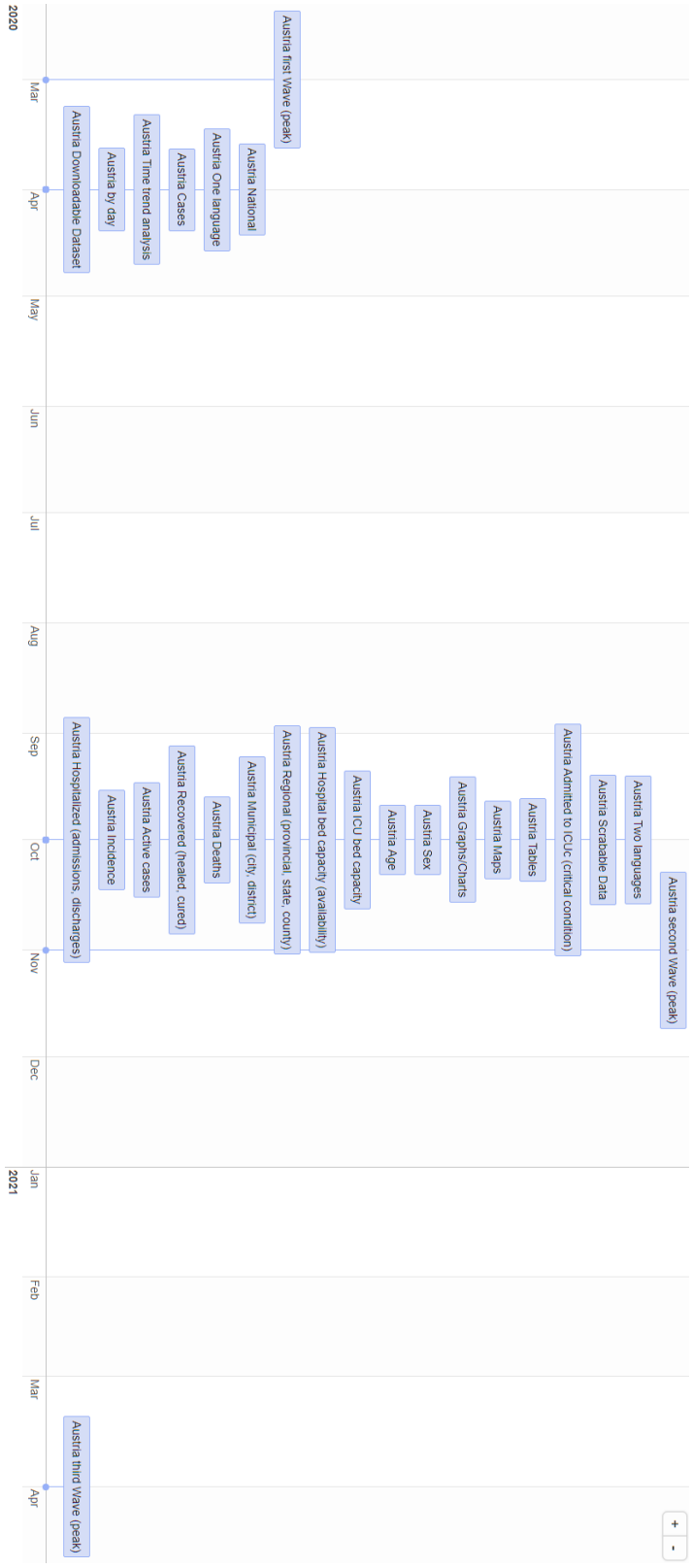

Figure 9: Case Timeline Austria

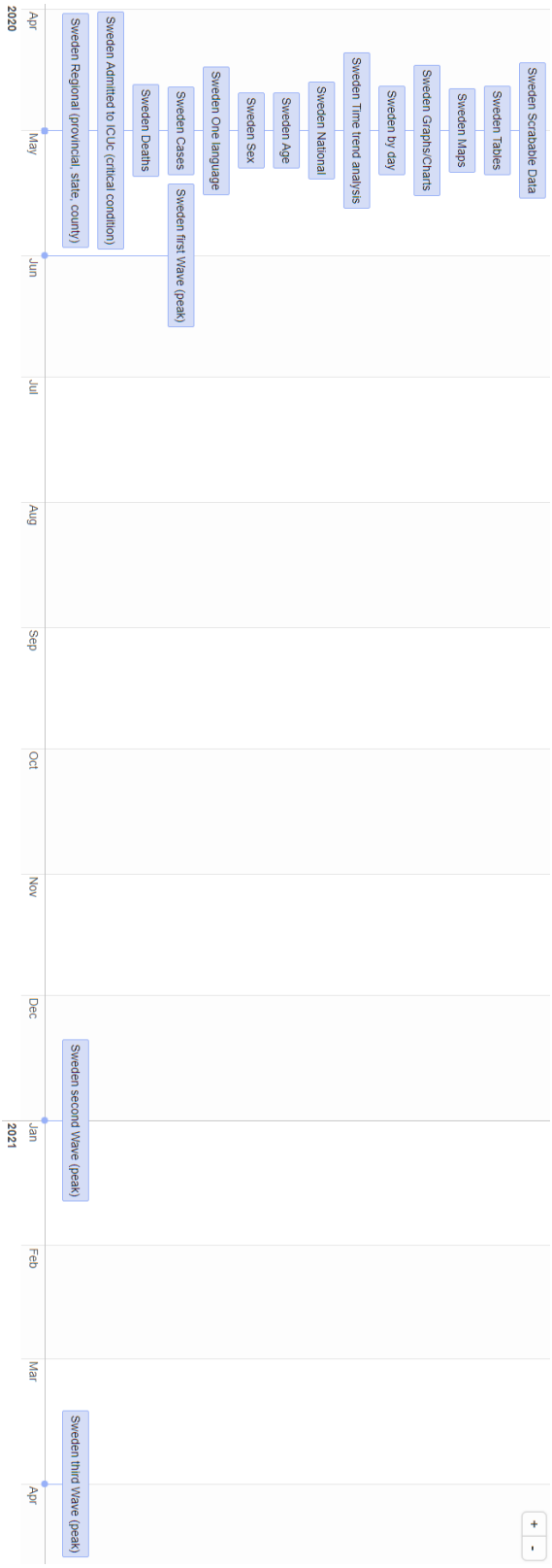

Figure 10: Case Timeline Sweden

5.2.2 Vaccines

Just as with the case dashboards, we can see some patterns within the vaccine dashboards. Most countries started their dashboards between the approval of the Biontech/Pfizer vaccine and the Moderna vaccine. The countries Bulgaria, Italy, Latvia and Spain, only added information in that time period and then stopped the extension of their vaccination dashboards. An example of the Bulgarian timeline can be seen in figure 11.
The countries Austria (figure 12), Germany and Norway did the same as the above-mentioned countries, but added further indicators to their dashboard after the approval of the AstraZeneca vaccination.
The remaining countries showed rather independent patterns. Luxembourg published only qualitative information on their dashboards after Biontech Pfizer, and added quantitative information only in April 2021. Ireland and France added the majority of their indicators after the approval of the AstraZeneca vaccine. Finland and Romania added their first information after the Pfizer approval, but added again to their dashboard later in March and April 2021. The Netherlands spread their dashboard adaptations over the complete timeline and added information to their dashboard after almost every vaccine approval. And Croatia seems to be bringing up the rear, having published their first dashboard figures only in May.
In summary, there seems to be a link between key events and the development of dashboards. Clear patterns can be seen in both the case dashboards and the vaccine dashboards.

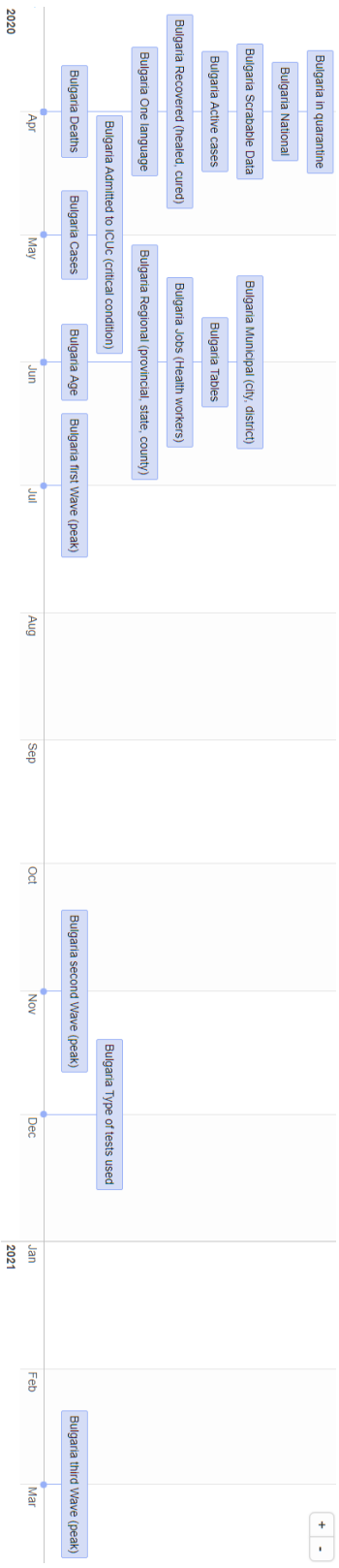

Figure 11: Vaccine Timeline Bulgaria

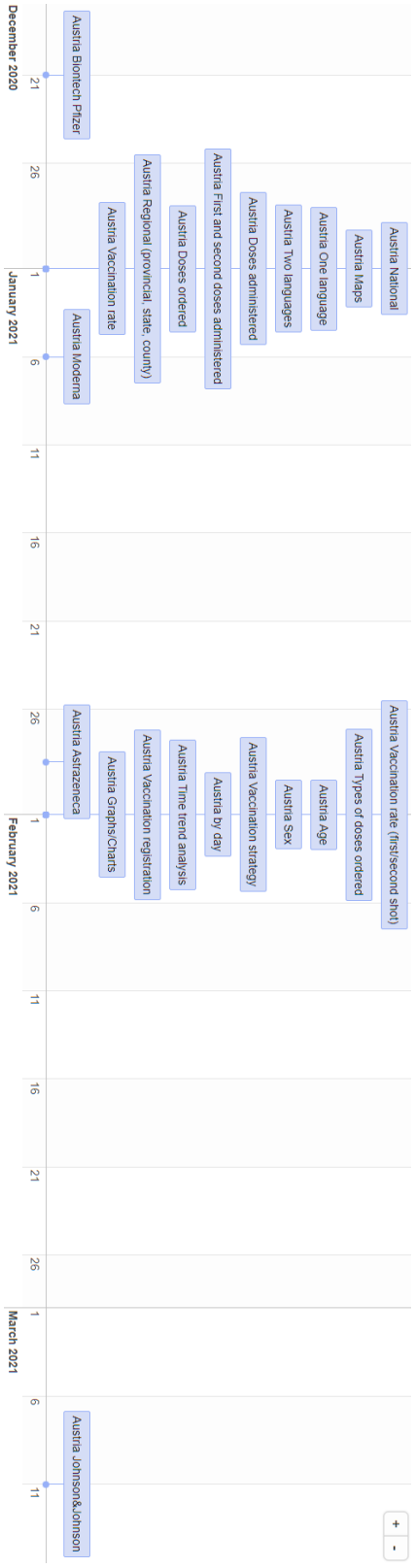

Figure 12: Vaccine Timeline Austria

5.3 Special Indicators

While reviewing the individual dashboards, we noticed some special indicators that were unique to the individual dashboards and therefore not listed in our panel. In this section we want to point out the different 'special' indicators that were provided by the countries.
Belgium, for example, published mental health indicators on their dashboards. Those indicators included a time series plot about the percentage of adults with depression disorder as well as the amount of suicide attempts and amount of prescribed antidepressant. Most of these indicators included filters for regions, age groups and gender. On top of that Belgium also reported the percentage of people with antibodies in their blood. The amount of antibodies were listed separately for blood donors, healthcare workers as well as children and school staff.
The Netherlands also provided three special indicators. The first one being the amount of Covid-19 in the wastewater accompanied with a timeline as well as a map by municipalities and region. The second one was information about the average number of people that were compliant with basic Covid-19 rules. The average compliance was reported for each rule individually along with a timeline, a regional map, and a distinction in age groups. The last special indicator was an addition to the vaccine dashboard which showed the willingness to get vaccinated among age groups in a time series plot.
Lithuania reported a map that showed the number of new infections that were close to each other on a map in the form of bubbles. This is an interesting approach to reporting clustering on a dashboard. In our documentation we also noted, that Ireland had a similar feature, but upon further research it seems, that they have already removed this feature from their dashboard.
Very early in the pandemic, France also reported the patient transfers of patients with Covid-19, but this feature was also very quickly removed from the dashboard.
Poland also reported a rather unusual indicator on their vaccine dashboard by stating the total amount of vaccine doses thrown away.

5.4 Rankings

To allow for a fair comparison of the different dashboards, we created a ranking that takes our documented data [24] as an input and outputs a comparable score for each country. The ranking mainly takes into account the amount of information published on the dashboards but also values the type of information published. It is important to note that this ranking does not evaluate the overall data quality of the dashboards, since it only focuses on

the amount of information published on them.

In order to arrive at a comparable scoring, we linked every indicator on our panel [7], to a score of either 0.5 or one, depending on the type of information provided by the indicator. That is, we gave (subjectively chosen) more important and common "key" indicators a score of one, whereas rarer indicators where asssigned 0.5 points only. We emphasize that the ranking and scoring system could be improved more systematically (e.g. weighing importance by overall availability of certain indicators across all dashboards or alike), which we leave to future work, cf. Section 6.1. All indicators in the sections 'Level', 'Languages available', 'Presentation', 'Data' and 'Risk Management' got linked to a value of 0.5. All the other indicators from the sections 'Public health and epidemiological numbers', 'Testing', 'Health system management' and 'Vaccination numbers' got linked to a value of one. As you have probably noticed, the sections linked to the value of one contain the 'key figures' the dashboards are based on, while the other sections are focused on describing those key figures. Therefore, the reason for the different indicator values is to give dashboards that provide a greater variety of 'key figures' a highers score than dashboards that just provide one 'key figure' and describe it in various ways. After assigning the values to the different indicators, we started to calculate the scores for each country. For each country, the values of the indicators documented for the country were added together. For example, if an imaginary country provided the the number of Cases (1 Point) and Deaths (1 Point) on a National (0.5 Points) and Regional (0.5 Points) Level presented in a Map (0.5 Points) and a Table (0.5 Points) available in two languages (0.5 + 0.5 Points) it would end up with a score of 5 for its case dashboard. This procedure was carried out per country and per panel with the help of Microsoft Excel. The maximum possible score was 29 points for the cases dashboard and 21.5 points for the vaccines dashboards, resulting in a maximum total score of 50.5 points. It is important to note, that indicators that got removed over the time period were not included in the scores.
The results were two different scores for each country. One for the case dashboard and one for the vaccine dashboard. We summed up those two values for each country and created a ranking based on the total score. The result can be seen in table 3.

For the case dashboards the top countries are the Czech Republic (18.5 Points) and Belgium (17 Points) followed by Austria (16 Points), Germany as well as Denmark (both 15.5 Points). All of those countries reported a major amount of the indicators listed in the public health, testing and health system section, combined with a diverse presentation and a very detailed level

Country	**Cases**	**Vaccines**	**Total**	**Rank**	**ODIN Rank**	**ODIN Score**
Austria	16	14	30	1	15	68,7
Belgium	17	10,5	27,5	2	26	45,5
Czech Republic	18,5	9	27,5	2	14	69,8
Germany	15,5	11,5	27	4	8	77,3
Netherlands	13	13,5	26,5	5	5	81,5
Denmark	15,5	10,5	26	6	3	84,4
Estonia	14	11,5	25,5	7	12	70,2
Slovenia	13	12	25	8	6	79,9
Norway	12	12	24	9	7	79,1
Poland	10,5	11	21,5	10	1	85,3
Luxembourg	14,5	6,5	21	11	19	65,1
Finland	10,5	10	20,5	12	2	84,8
France	15	5,5	20,5	12	21	62
Iceland	12	8,5	20,5	12	23	52,8
Lithuania	13,5	7	20,5	12	10	73,8
Croatia	13	6	19	16	20	63,8
Italy	8	11	19	16	18	65,9
Bulgaria	13	5,5	18,5	18	13	69,9
Sweden	8,5	8	16,5	19	4	83,9
Ireland	10,5	5,5	16	20	9	77,1
Portugal	12	3	15	21	16	66,5
Romania	8,5	5,5	14	22	17	66,2
Latvia	9	3,5	12,5	23	22	58,2
Spain	7,5	5	12,5	23	11	71,3
Malta	6,5	0	6,5	25	25	47,2
Liechtenstein	5	0,5	5,5	26	24	48,8
Average	12	7,9	19,9			69,2
Median	12,5	8,25	20,5			69,85
Min	5	0	5,5			45,5
Max	18,5	14	30			85,3

Table 3: Dashboard Ranking

of information. Unlike the other countries the Czech Republic also reported their ventilator capacity as well as their personal protective equipment stock, securing the country the first place in the ranking.
The two worst rated countries for the case dashboards were Liechtenstein (5 Points) and Malta (6.5 Points). Liechtenstein only reported one time trend graph on a national level, showing their cases as well as a 7-day incidence, while Malta's dashboard consisted of a daily updated .png file, providing information about cases, deaths, recoveries and tests. Even though the amount of information on the Malta dashboard was a lot more, the dashboard still lacked any kind of graphical presentation, therefore its overall score is not much higher. On average, countries had a score of 12 Point, which is fairly low considering the maximum possible score of 29 points.
Figure 13 shows a map containing the cases dashboard scores from Table 3. The map uses a traffic light color scheme to display the average rankings, green indicating a good score, orange indicating a medium score and red indicating a bad score. When looking at the map, we can see that middle as well as western Europe provide high scoring dashboards. Northern, eastern and southern Europe seem to lack behind on their cases dashboards, according to the scores.

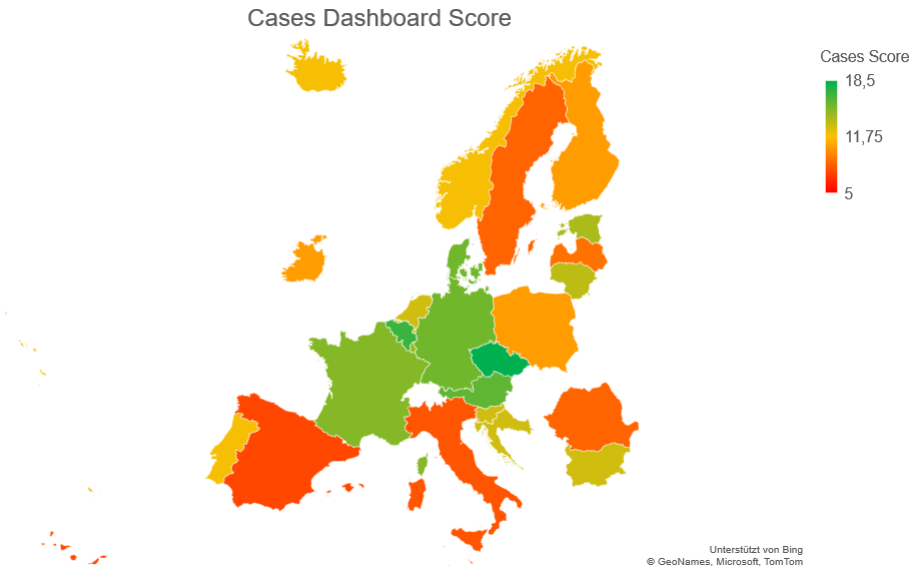

Figure 13: Cases Score Map

For the vaccine dashboards the top countries are Austria (14 Points),

the Netherlands (13,5 Points), Slovenia and Norway (both 12 Points). The Netherlands published by far the most indicators in the Vaccination numbers section, but unlike Austria and Slovenia, the Netherlands only reported at national granularity on their dashboard. Other than the other countries, Austria provided a direct link to the vaccination registration on their dashboard and provided a variety of presentation techniques, which in the end, was enough to score slightly better than the Netherlands. The two worst vaccine dashboards belonged to Latvia (3 Points) and Spain (4 Points). Both countries reported their data solely on a national level and kept the information about their vaccination numbers to a bare minimum. Unfortunately, we were not able to find an official vaccine dashboard for Malta, which is why the country has zero Points in the Vaccines column. Same goes for Liechtenstein, they only provided a downloadable data set on their case dashboard. The average score for the vaccine dashboards is 7.9, which is again fairly low, considering the maximum possible score of 21.5.
Figure 14 again shows the score of the vaccines rating from table 3 on a map, with a traffic light colour coding. We can see that the majority of central Europe as well as northern Europe and Italy scored fairly well in our vaccines ranking. By comparing figure 14 with figure 13, we can observe some differences. France for example turned from light green in our cases map into orange in our vaccines map, indicating that even though their cases dashboards was above average, their vaccine dashboard does lack behind. In northern Europe as well as Poland we can see the opposite change. While this countries scored below average in the cases ranking they happen to perform above average in the vaccines ranking.

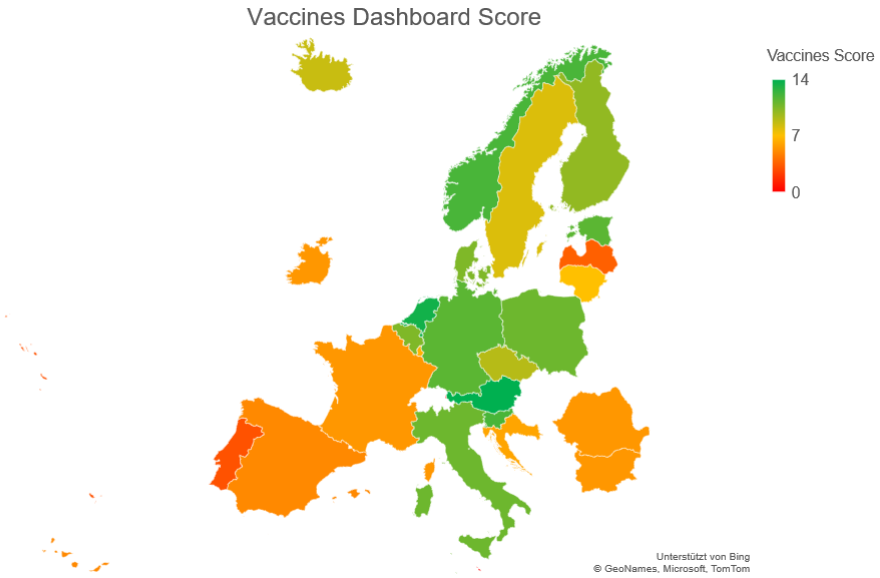

Figure 14: Vaccines Score Map

If we take a look at the total scores, we can see that Austria, Belgium, the Czech Republic and Germany are on top while Malta and Liechtenstein draw the bottom line. Of course, we also created a map showing the total scores of the countries in figure 15. Just like on the other two maps before, most of central Europe performs above average with their dashboards. We can also see that the dashboard quality seems to fall off in western and southern areas. Northern Europe seems kind of like a mixed bag on this map. While Norway and Finland provide above average dashboards, Sweden lacks behind in both the case dashboard and the cases dashboard. The same can be said for Latvia when comparing them with Estonia and Lithuania.

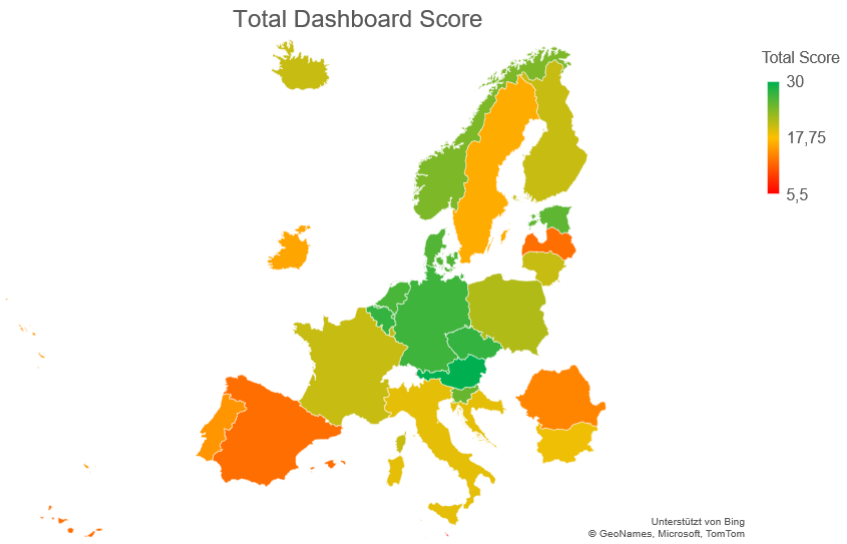

Figure 15: Total Score Map

5.4.1 Open Data Inventory (ODIN)

Since our ranking (see section 5.1) is intended to represent transparency and openness about the pandemic data per country, we additionally tried to compare our ranking against realted rankings of other institutions in the context of transparency and Open Data at national level. To do that we decided on using the 'Open Data Inventory' as our ranking of choice since it includes all of the countries used in our analysis. To clarify, the Open Data Inventory (ODIN) is defined as follows:

> ... an evaluation of the coverage and openness of data provided on the websites maintained by national statistical offices (NSOs) and any official government website that is accessible from the NSO site [27].

Just like our Analysis, ODIN looks at official government sources to determine a country specific open data score. It thereby does not only focus on health related data, but also on a variety of social, economical and environmental data. ODINs total score consists of two category scores, one for data coverage and one for data openness [27]. In our analysis we will only consider the total score. The data we use is from ODINs 2020 Annual Report, which include the ranking of 187 different countries [28]. A brief comparison of the overall score for all countries from our analysis can be seen in figure 16.

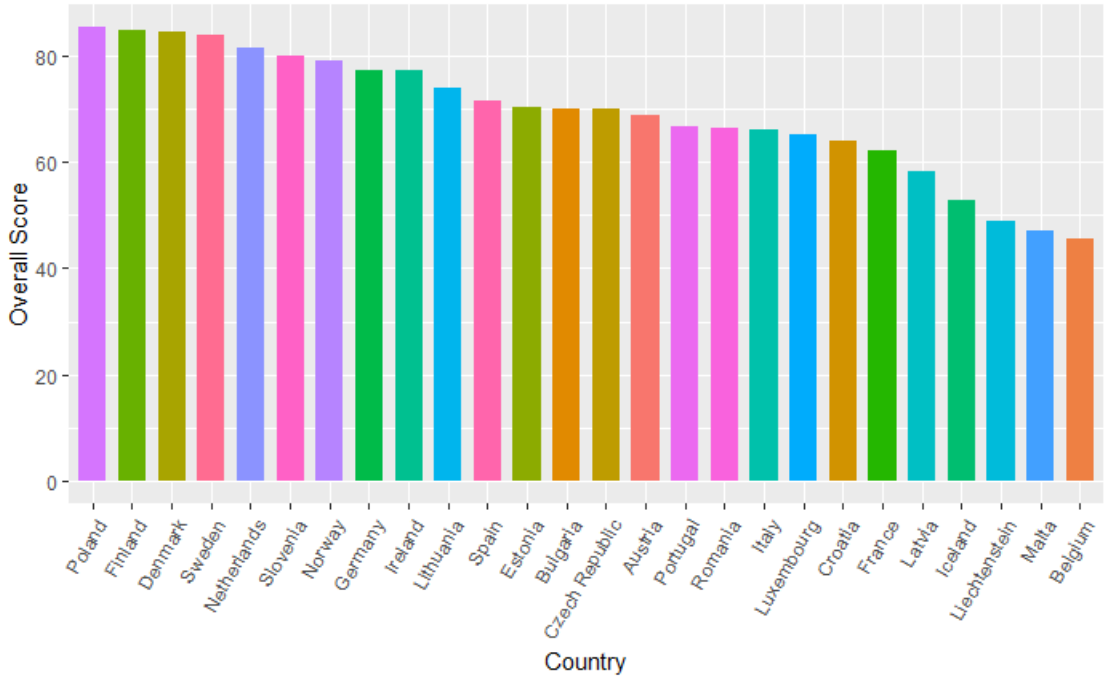

Figure 16: ODIN Scores

The first thing that stands out when looking at the score comparison in table 3 is that our three top ranked countries are far from the top ten of the ODIN score. Belgium, the country that ranked second in our analysis, even has the worst score from our list. Nevertheless, our ranking still seems to coincide with that of ODIN. Looking at the bottom of our ranking we can see that Malta and Lichtenstein, the two countries that score worst in our Ranking, also scored fairly low in the ODIN Ranking. We can also see that all top 10 ODIN rankings can be found towards the top of our table 3, while lower rankings tend to be found towards the bottom. The largest outliers in this respect are Sweden and Ireland. Countries which are among the top ten according to the ODIN ranking, but are in the bottom half according to our rankings. To check how well our score correlates with the one from ODIN we performed a simple linear regression, the results of which can be seen in figure 17. The result is an estimated positive effect of 0.2 of the ODIN Score on our own total score. This means, that one additional point in the ODIN Score translates to 0.2 additional points in our own score. This result is significant with a p-value of 0.03. Overall the evaluation indicates, that transparency and policies in regard to the pandemic do not necessarily correlate with historical policies in regard to transparency and openness.

Reasons for this could be situational differences of the Covid-19 impact.

```
Call:
lm(formula = Total ~ ODIN_Score, data = reg)

Residuals:
    Min      1Q  Median      3Q     Max
-9.8135 -4.7932  0.0433  3.4798 12.9355

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   4.2366     7.0528   0.601   0.5537
ODIN_Score    0.2270     0.1005   2.257   0.0334 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 5.902 on 24 degrees of freedom
Multiple R-squared:  0.1752,    Adjusted R-squared:  0.1408
F-statistic: 5.096 on 1 and 24 DF,  p-value: 0.03335
```

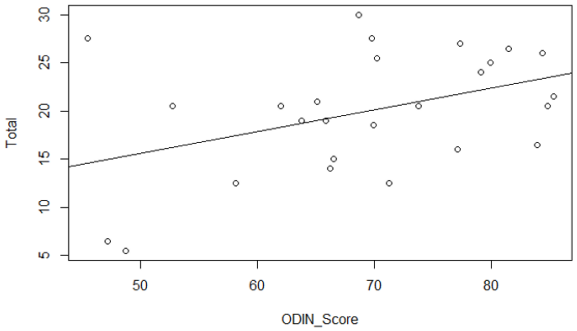

Figure 17: Total Score ODIN Score regression

6 Discussion

To begin this discussion we would like to recap our research question(s). What data is made available via European Covid-19 dashboards, and how have those dashboards evolved over time? In order to approach the topic, we tried to orientate ourselves on previous scientific work that dealt with countries and their Covid dashboards. The most similar work we found was a paper by Ivancovic et al. [29] which included a content analysis of 158 Covid dashboards. Based on this paper we created two panels to document the information provided on the dashboards. After retrieving the sources for the official governmental Covid dashboards of 26 European countries we started to document them with the help of the Wayback Machine. This allowed us to extend the research done by Ivancovic et al. by a temporal component.
In the first step, we ranked the countries based on the extent of the dashboards. The winner of this ranking was Austria, the reason for which could be the relatively high number of infections per 100,000 inhabitants [18]. However, among the countries compared, there were some that were hit much harder by Covid-19, so the exact reason remains open for discussion. A comparison of our ranking with the official open data ranking ODIN showed us that the dashboard score correlates with the open data ranking, even with a few outliers.
To answer our question regarding the type of data published on the dashboard, we took a closer look at the indicators from our panel. Unsurprisingly the most common indicators reported on the dashboards were national case

and vaccination numbers. The number of covid related deaths was also reported by a fairly high fraction of the countries, but no one reported a related mortality rate. This could be related to the fact, that most countries had a hard time counting Covid-19 deaths and were therefore not ready to set the reported number in relation to the actual number of cases. What was especially suprising to us was, that less than 15 percent of the countries provided information about their related equipment stocks and bed capacities. This information would have been especially relevent since most of the NPIS imposed by the governments were based on not exceeding the available capacities. On top of that the availability of the data was also quite scarce since only a few countries provided a downloadable dataset on their dashboards.
In the next step we tried to look at how the informations on the dashboards have evolved over time. The earliest indicators found on the dashboards were national and regional tables showing the number of cases as well as recovered patients. This makes sense since tables seem to be the least complicated way of reporting data. The number of deaths and an overall better presentation of the data was added later on. The next step included, adding information about the number of tests performed and a distinction by age groups. In the final steps the dashboards started to report, first all ICU patients and then all hospitalized patients. Based on the evaluation, we assume that most countries initially tried to publish data on their dashboard as easily as possible. In the course of time, the information was then supplemented with further details and presentation options. We also assume that the information added was almost always related to the different stages of the pandemic. The number of deaths was added in April which was the first month, worldwide Covid-19 deaths surged significantly. The number of tests were added in May, which was the months in which countries started to discuss lifting their restrictions. Therefore they needed a new tool to counter the pandemic, which turned out to be regular testing. Adding information about age groups during that time also makes sense since tracking infections in older age groups important to prevent hospital congestion.
The same evaluation was also performed for the vaccination dashboards. In January of 2021 the countries started to report the number of shots administered and added a distinction for first and second shot about half a month later. Unfortunately, the other interesting indicators about the vaccination stock were not reported by enough countries to build a reliant time trend. This may be due to the early collection of data, which only lasted until June 2021. It is to be expected that many countries expanded their vaccination dashboards after this deadline.
In a further step, we looked at the development of the dashboards, using timelines, for each country individually. In the process, we noticed some

patterns. When it comes to case dashboards, there were pioneers and learners. Pioneers added indicators to their dashboard during the first wave, but then added no or very few new indicators during the rest of the pandemic. Learner on the other hand added only few indicators during the first wave, but extended their dashboard during the build up of the second wave. If we compare the patterns with our country ranking, we see that countries with a learning pattern perform better on average than those with a pioneer pattern. We assume that the countries with a learning pattern have taken their cue from the other countries in adapting their dashboards and have thus been able to build more comprehensive dashboards. With regard to the case dashboards, it can generally be said that the majority of the indicators were added to the dashboards after the approval of the Biontech Pfizer vaccine. Thereafter, the approach of countries was relatively different, with most adding further indicators at a later stage.
In the course of our dashboard documentation, we also noticed some special indicators that were only occasionally reported by countries and therefore did not appear in our panels. These included depression indicators, Covid-19 antibodies in blood donors, patient transfers, cluster maps, water quality indicators, discarded vaccine doses, vaccination compliance and compliance to Covid-19 measures. Belgium and the Netherlands in particular stood out in this additional survey, because they published the highest amount of additional indicators. What was also interesting to observe was that some of the additional indicators were removed shortly after they were added to the dashboards. These included, for example, the patient transfers in France and the cluster map in Ireland. We suspect that the continuation of these indicators would have become too complicated as the number of infections increased.

6.1 Limitations and Future Research

To recap, in this thesis we produced a data set documenting the content of the official case and vaccination dashboards of 26 European countries. The dataset is limited by region, as it only includes the data from 26 European countries. Its content is also limited to official government dashboards, which means that indicators provided by other sources such as newspapers or official governmental datasets are not taken into account. For future research, it would be interesting to extend the regional limitation of the work to non-European countries, to allow for a more international comparison. One could also analyze the indicators published on non-official dashboards (eg. provided by news companies). Also, the documentation of the dashboards in this

thesis was semi-automatic. By fully automating the documentation one could provide more regular evaluations of the current dashboard situation. Another limitation is that earlier versions of the dashboards that were available via another link, which was neither on the website of the respective Ministry of Social Affairs nor stated on the ECDC reports, are not included in the evaluation. Future research could also focus on creating a country ranking, which does not only focus on evaluating the amount of information published on the dashboards, but also focuses on the overall Covid-19 data quality of the countries. One could also focus on documenting the different indicators in a much more detailed way by not using the simplified documentation method described in chapter four. The Covid-19 pandemic is still a very topical and fast-moving issue. In the meantime, the third vaccination has already begun and more new virus mutations are being discovered. Depending on the vaccination rate in the respective countries, we may see the number of infections rise again. All these new developments can be taken into account in future research.

7 Conclusion

In order to make risk-minimizing decisions in the context of the Covid-19 pandemic, it is important that both the government and the population have a clear view of the state of the situation. In this context, Covid-19 dashboards give both parties the opportunity to receive a near real-time status update. The quality of this status update is strongly related to the variety of information provided on the dashboards. Our evaluations show that the dashboards were regularly adjusted during the pandemic to provide information that was important at the time. Nevertheless, a clear difference in the quality of the dashboards can be seen when comparing countries. In order to ensure that the data situation in all countries is as transparent as possible in the future, it is important that the dashboards are further expanded and that countries that are currently performing worse in comparison work on improving their dashboards.

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A. Attachments

Dashboards_v2_Auswertungen.zip
Download: https://github.com/felixhelm/COVID-19-Dashboards.git
Contains:

- Dashboard Sources
- Documented Dashboard Panels (used dataset)
- Calculations and data from Chapers 5.1 and 5.2

Timelines.zip
Download: https://github.com/felixhelm/COVID-19-Dashboards.git
Contains:

- R Code for the Timelines (Chapter 5.3)
- ODIN Score / Total Score regression model

Waybackscript.zip
Download: https://github.com/felixhelm/COVID-19-Dashboards.git
Contains:

- Python script used for the Dashboard documentation (Chapter 3.4)

Timeline_Screenshots.zip
Download: https://github.com/felixhelm/COVID-19-Dashboards.git
Contains:

- Pictures of all created Timelines