ABSTRACT

Timely, credible, and fine-granular case information is vital for local communities and individual citizens to make rational and data-driven responses to the COVID-19 pandemic. This paper presents the CovidNet, a COVID-19 tracking project associated with a large scale epidemic dataset, which was initiated by 1Point3Acres. To the best of our knowledge, the project is the only platform providing real-time global case information of more than 4,124 sub-divisions from over 27 countries worldwide with multi-language supports. The platform also offers interactive visualization tools to analyze the full historical case curves in each region. Initially launched as a voluntary project to bridge the data transparency gap in North America in January 2020, this project by far has become one of the major independent sources worldwide and has been consumed by many other tracking platforms. The accuracy and freshness of the dataset is a result of the painstaking efforts from our voluntary teamwork, crowd-sourcing channels, and automated data pipelines. As of May 18, 2020, the project has been visited more than 200 million times, and has empowered over 522 institutions and organizations worldwide in policy-making and academic researches. All datasets are openly accessible for non-commercial purposes at https://coronavirus.1point3acres.com via a formal request through our APIs.

1 INTRODUCTION

Starting from December 2019 or earlier, the outbreak initially detected and reported in Wuhan (Hubei, China) due to a novel type of coronavirus, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has been rapidly spreading firstly across regions in China and east-Asian countries, and then, since the late February, to nearly all continents in the world. As of May 15, there have been more than 4.42 million cases confirmed across 225 countries and regions, associated with 302 thousands deaths. Declared as a pandemic by World Health Organization on March 11, the coronavirus outbreak has brought severe challenges to not only local medical systems (especially in underdeveloped areas) but our society as a whole.

Governments across the world have been taking various measures at different levels in response to the pandemic. To be able to make scientific and data-driven decisions, local communities are relying on timely and accurate epidemic data to understand the spread and the trend of the COVID-19 outbreak. Case information in cities and/or provinces is especially valuable to promptly adjust local policies in response to the rapid change of the pandemic situation. At the same time, nearly every individual’s daily life has been severely affected by the crisis. To minimize the ramification of community spread, it is of extreme importance to provide the public with transparent and accurate local information to guide their daily life decisions. Overall, there is a huge need for timely,
We have been providing data both to the public and academic with our real-time case data. CovidNet has been visited more than 200 million times and has empowered institutes for pure research purposes. As of May 18, 2020, the project CovidNet features:

- World data with regional breakdown.
- Timely update.
- Data accuracy and consistency.
- Worldwide data with regional breakdown.

Our COVID-19 dataset, named as CovidNet, offers the full historical case trends with a fine-granular regional breakdown. The name addresses the hierarchical structure of the geographical network the data is embedded in. CovidNet is constantly being updated to include the most up-to-date case information in real-time. To achieve data accuracy, real-time update, and worldwide coverage, the CovidNet features:

- The data is collected from only reliable sources. Various quality control assurances have been applied;
- The data is updated in real-time with the effort of crowd-sourcing and automated data collection;
- The data is collected with fine geographical granularity worldwide.

We have been providing data both to the public and academic institutes for pure research purposes. As of May 18, 2020, the project has been visited more than 200 million times and has empowered over 522 institutions and organizations. We have built a convenient application programming interface to access the CovidNet dataset. And, to assist the worldwide battle against COVID-19, we would like to encourage more users, with both governmental and academic backgrounds, to take advantage of our data collection.

The rest of the paper is organized as follows. Section 2 provides an overview of the 1Point3Acres CovidNet project on both datasets and visualization. We discuss our data collection practice in details in Section 3 (North America data) and Section 4 (global data). We elaborate our quality control mechanism in Section 5, and introduce the rich set of interactive visualization tools in Section 6. In Section 7, we explain briefly about how to access our datasets; related projects and platforms are mentioned in Section 8. We summarize our work in Section 9 and discuss various ways that CovidNet could aid the battle against COVID-19. A disclaimer is highlighted in the end emphasizing the role of the CovidNet Project and associated contents.

## 2 PROJECT OVERVIEW

Since the beginning of the COVID-19 outbreak, there has been overwhelming related information from numerous resources. A major challenge, therefore, is to integrate the scattered information on a single platform with consistent quality and credibility. The 1Point3Acres project focuses on the following three aspects in collecting and presenting the CovidNet data:

- **Data Accuracy and Consistency.** We extract information from local health authorities and trustful media reports. Media reports are used when official data is significantly delayed, and are cross-checked with official data afterwards. No data from other tracking platforms is used in CovidNet to eliminate loops of references.

- **Timely Update.** Since the launch of our project, CovidNet data has been updated in nearly real-time. Crowd-sourcing has been implemented to ensure timely updates. This sets us apart from official channels like WHO [7] and U.S. CDC whose updates are delayed by days. To our best knowledge, most other non-governmental platforms [4, 6] have also experienced a 1 - 2 days delay by far.

- **Worldwide Data with Regional Breakdown.** CovidNet provides case information with finer geographical granularity in over 27 countries and we are still expanding the coverage. After the initial launch with county-level case data in the U.S. and Canada, we have received numerous feedback from local authorities and residents on how it helped local communities in decision making, which motivated us to bring the finer data granularity to more countries impacted by COVID-19.

### 2.1 CovidNet Dataset

Our CovidNet dataset provides real-time epidemic information in three major categories: confirmed, deceased, and recovered cases when they are publicly available. The complete history since the outbreak in each local region is available in the CovidNet dataset.

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1. We follow the definition of different categories provided by health authorities in each country.
Table 1 summarizes granularity, information source, and update frequency of the current dataset.

| Granularity       | U.S./Canada | Hardest Hits* | Others |
|-------------------|-------------|---------------|--------|
| Number of regions | 3169        | 974           | 161    |
| Original sources  | health dept. | health dept. & | WHO    |
| Update frequency  | 1 hr         | 1 hr           | 2 hrs  |
| Cumulative cases  | 1.5M         | 1.9M           | 1M     |
| Total Deaths      | 92K          | 161K           | 49K    |

Table 1: Summary of CovidNet dataset. *We now have included 27 countries, with more to come.

2.2 Interactive Tools on 1Point3Acres Tracker

Figure 3: Example visualization tools for geographical distribution. Left: county level interactive case map in state of New York, U.S. Right: a doughnut chart of case distribution in U.S by states. Figure best visualized in color.

Figure 4: Example burn down charts for visualizing trends of active, deceased, and recovered cases in Lombardia, Italy.

With a flood of available COVID-19 data, we offer a suite of interactive analysis and visualization tools to provide the general public more insights about the current situation of the COVID-19 pandemic. We focus on presenting both the temporal trends (i.e., epidemic curves) as well as the geographical distribution of the case spread. (See Section 6 for details.) The interactive tools are available in four different languages.

- **Geographical Distribution.** The COVID-19 case distribution is presented in various ways, including epidemic maps, doughnut charts and tabular views. Figure 3 showcases a few examples of visualization. World, State, and county level epidemic maps are provided for user exploration. The tabular view can be customized to rank by different case dimensions, such as the infection rate, the death rate, etc.

- **Temporal Epidemic Curves.** Temporal trends of the outbreak are captured in various epidemic curves, including basic time-series lines and burn down charts. Users can choose and compare curves of different regions with our interactive tools. One such example is shown in Figure 4.

3 NORTH AMERICA DATA COLLECTION

The United States has been the epidemic center since March, 2020, and the most challenging area to integrate creditable case information in real-time due to data inconsistency at different levels of the public health system. Our platform was initially launched to confront this challenge and the severe delay by official authorities. This section describes our data collection and validation practice during different stages of the outbreak amid a timely, reliable, and county-level COVID-19 dataset.

Before discussing the data collection practice in detail, we highlight the specific features of the CovidNet dataset in the U.S. and Canada in addition to Section 2.1. The tracking in North America started on January 21, 2020 when the first case was officially confirmed in the U.S. The data covers 3169 sub-country-level regions across the North America. All data is collected from publicly available sources, including both local health official announcements and reliable media reports, and is integrated from 1064 distinct websites. In addition to case information, our project also includes testing locations and statistics thanks to the COVID Tracking Project [1].

3.1 A Change Log of Data Collection Practice

The epidemic situation underwent several stages in North America since January 2020, each with unique challenges in data collection and validation. We now elaborate different stages of the data collection practice along with the evolution of the COVID-19 outbreak.

3.1.1 Initial stage: January to Late February. The first North America COVID-19 case was officially reported on Jan 21 [5] and the total cases had remained at a low level until late February. During this period, both federal and local official health departments had not developed a systematic reporting schedule. Each individual case, however, received plenty of media coverage with both geographic and demographic details. The most timely data source had been local media reports.

The CovidNet project was initially launched in Jan 31, 2020 as a platform for real-time case data aggregation of related media report [5]. Since active crowed-sourcing was the most effective way to track the sparsely emerging cases, we organized a volunteer team working 24/7 for real time updates and focused on data accuracy.

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*The geographical granularity differs in different countries, although one shall not interpret that the official US/Canada data has a better granularity than ones in other countries. While city level and per-case level case data are accessible in many regions outside U.S./Canada, systematically aggregating such information worldwide, however, is beyond the capability of our voluntary team.

*This includes all counties/districts in U.S./Canada, U.S. Federal Bureau of Prisons system, U.S. Military and Veteran Affairs systems, and U.S. territories. Cases from cruises have been separately presented.

*As of Feb 29, 2020, a total of 72 cases were officially reported in U.S. and 20 in Canada.

*Our searching had traced media sources including CBSN (U.S.), Seattle Times (U.S.), Global News (Canada), National Post (Canada), etc.
We recorded each single confirmed case with all accessible data features including geo-location, demographic information, infection cause, and a summary of news report. In additional to per-case information, the reference links to original news were also attached to each record in our dataset and were visible to all users on the website. This helped us account for double counting and to cross validate against later official reports.

3.1.2 Expanding stage: Late February to End of March. The epidemic outbreak in North America started expanding geographically since late February. While numbers were still closely tracked by local media, the task of integrating all available sources manually by volunteers had become more and more challenging. Health official departments also started to actively release case information but yet to provide a real-time data. With limited capacity, in addition to active searching for media reports by volunteers, we offer an issue report submission form to all users, through which anyone can provide useful information back to us. The submission form categorizes information reports into 9 different classes: "New Case", "Recover Case", "Death Case", "Error Report", "Feature Request", "Breaking News", "Further Details", "Testing Location", and "Question". Whenever a delay of our data or an error was noticed, a user could directly report the issue to us with trustful links. This helped us account for double counting and to cross validate against later official reports.

We want to address the three important facts below about our automated official-data checking pipeline:

(1) We collect both official health authority reports and media report to stay close to real-time.
(2) While most official health authority provide case data to public, it remains of significant importance to integrate all local data into a complete dataset.
(3) We account for potential noise in data from local health officials and implement various quality assurance steps before adding into our database.

This automation pipeline has been integrated into our workflow since April, 2020, and has become one of the dominant components of our data collection process.

3.2 The Structural Evolution of the Data Format

We used the cloud collaboration service provided by Airtable. Our team members can simultaneously work on the same tabular data. There are three major tabular formats we have used:

- **Expanded Tabular (ET) format**: we document every case (sometimes a small cluster of cases) into a single row to provide a per-case view to our user. We also provide a summary of the original report for each case-cluster. In this ET format, all information including the reference link to the source is presented directly to users for the full transparency.
- **Compact Tabular (CT) format**: given a table content topic (e.g. recovered case table) and a fixed (geographic) granularity, we assign each row with a region, and each column with a date. The number in a cell therefore indicates the accumulative counting in the row-labeled region on the column-labeled date. And each row represents a time series of data in a specific region. While CT is easy to consume compared to ET, the CT format cannot easily summarize the full set of references and loses certain demographics information. We keep such dimensions only internally visible for quality control purpose.
- **Statistic Assistant (SA) format**: this type of table is used to present statistics of currently collected data. We usually assign each row a region, which could be of country-equivalence level, state-equivalence level, or county-equivalence level. Different columns are used to represent different information categories associated with each region like region name, total confirmed number, fatality rate, contact of the local health official. SA is mostly used for tabulated presentation and other interactive maps on our project web-page.

During initial stage (section 3.1.1), we used a single database to record all cases in the ET format. It was later divided into two separate ones in early March: one for U.S. cases and the other for international.
Canada cases. Corresponding SA tables have also been updated automatically since then.

The ET format continued to be the dominant one until the end of the Expanding stage (section 3.1.2). Maintaining ET format when U.S. official only reports aggregated statistics became impossible and we have transformed our data table into the CT format in late March. We kept deceased case table and recovered case table in ET format until mid-April and transformed into CT format then.

4 WORLD WIDE DATA COLLECTION

Most mainstream COVID-19 data platforms [3, 4, 6–10] offer case information at country-level, with only exceptions for China by [3] and North America (e.g. by our project and subsequent platforms that aggregate our data [4, 9]). International organizations like WHO [7] and ECDC aggregate worldwide data but are often delayed without sub-division regional breakdown. Creating a platform with consistent freshness, credibility, and granularity for worldwide data is the key to present the full picture of the COVID-19 spread, which, however, poses a great challenge.

Determined to confront this challenge, we have exploited a combination of manual data collection, crowd-sourcing channels, and automated data pipelines to solve the problem. As of May 18, 2020, the CovidNet dataset has covered data in 1055 state-level regions and 3169 county-level regions of more than 27 countries and territories. While collecting the most updated data in a timely fashion, we also retrieved all the case history since the outbreak within each region.

We choose to only present daily aggregated numbers in CovidNet in each region for consistency. We note that some health departments have provided richer information than a daily aggregated number. A full list of countries can be found in Appendix. We prioritize countries with the most confirmed cases and attempt to cover major countries in all continents of the world. We highlight that this is an ongoing effort to expand to as many countries as our resource permits.

Subdivision Naming Convention. We adopt the ISO-3166 standard 7 to normalize provinces or states names in CovidNet. Official names in English and local languages are both available.

4.1 Case Reporting Paradigms in Different Countries

Local health authorities reports are used as data source for consistent credibility. While the data reporting systems differ across countries, they mostly fall into the following two categories.

The first class of countries offers open access to the full historical data starting from the outbreak. Within this paradigm, case information is provided in either the per-patient level or per-region daily statistic level. Examples are the public repository of Italy 9 and the open data API of Colombia 10. We transform all data into per-region-day statistics and discard detailed demographics. While this simplifies the full history retrieval, it requires systematical quality control, due to the modification of historical data and changes of reporting criteria. For instance, the official data repository of Spain changed confirmed case definition and data fields in late April, which led to mismatches in our time-series within a short time window. 11 We apply alarms whenever a suspicious decrease in the curve gets observed, which is then assigned to manual check by volunteers.

The second class of countries reports only the most recent case data, through a data-accessing interface. In most locales, the historical data is collectively archived and stored in various formats (pdf, csv, json), or retrievable from official daily reports. Examples include the official COVID report by Korean CDC 12 and the South Africa COVID news portal 13. We collect all archived information and create an integrated dataset. As in such data-accessing systems, there lacks a consistent way to track edits in historical data, we hence only retrieve the historical data once. Occasionally, we failed to trace back all the historical data archive. We resort to local non-official data platforms to backfill the earlier case data 14.

4.2 Data Collection Pipeline

We check all the official data sources every 2 hours and update the most recent data in our database accordingly. For countries that provide open access to the full case history, we also implement scheduled (daily) checking for modifications of official historical data. The timestamp associated with each record is in agreement with the local time of the publishing authority 15.

Given different stages of the outbreak, the data accessibility and publishing channels are constantly evolving in each country. For instance, official data is provided in per-patient level in the initial stage in most countries, and slowly evolves into an aggregated format during the outbreak stage. We combine our data pipeline along with the volunteer’s manual effort to ensure the data quality and consistency. Section 3 highlights this issue in the North America as an example.

5 DATA QUALITY CONTROL

The data quality control (QC) is always the first priority of the CovidNet project, as both local communities and researchers might make critical decisions based on the data. Note that we only have access to the case information released by health officials and/or media reports, and the quality of the original case data is beyond our capability. We control the CovidNet dataset to accurately reflect the information provided by local health authorities. This section focuses on specific quality control challenges in a rapidly evolving pandemic and the practices we adopted in the voluntary teamwork.

11 https://cnecovd.isciii.es/covid19#documentaci%C3%B3n-y-datos
12 Press Release Archive of Korean Center of Disease Control: https://www.cdc.go.kr/board/board.es?mid=a20402000006&bid=0030
13https://sacoronavirus.co.za/category/press-releases-and-notices/
14We specifically acknowledge the effort from [2] for their endeavor.
15We notice that a subset of countries provides official data with a 1-day delay, which is annotated accordingly on the web page.
5.1 Quality Control with different Reporting Paradigms Worldwide

As discussed in Section 4.1, our data comes from distinct reporting systems in different countries. While each paradigm requires a specific quality model, the general principle is to start with the data with the finest granularity and/or with the full history. For instance, when per-case data are provided (e.g. open data projects in Colombia and Philippine health ministries), the pipeline would aggregate from such per-case dataset to get daily case statistics and geographical distributions. Following the same principle, when health officials release and update the entire aggregated daily history (e.g., Italy and Spain), we update the entire time series whenever edits are made officially.

We dedicated our effort mostly in health reporting systems with a federated administration structure. The key challenge presented with such a system is the asynchronous nature of data from different levels. Taking the United State as an example: county health departments release case statistics following their own schedules while state officials may update at a lower frequency, typically 1-3 times a day. At any given time, aggregated county-level data may differ from state-level ones. In extreme cases, state-level reports could be delayed by days. This asynchronous nature has brought difficulty for QC. The situation gets further complicated when an unassigned category is presented.

Quality Control practice in federated systems: As discussed in section 3, our database records the finest granularity, and has included the full set of references either publicly visible (in the early stage) or internally traceable (in the current stage). All volunteers follow the same protocol to determine whether an inconsistency is due to human mistakes or not, by investigating data from different levels of health departments and also internal comments. On the website, a note would be left to users when presented numbers differ from official statistics. We also created an Inconsistency Diary (maintained by the volunteer team) as an internal reference to track discrepancies, and periodically revisit issues that persist.

5.2 Timely Updates with Potential Noise in Official Data

We acknowledge that any case data is subject to edit and change in a rapidly growing pandemic situation, and have assumed potential noise in the official data collected. While most of noise would be corrected eventually, to present timely update, we have categorized several noise mechanisms and implemented quality assurance accordingly.

• **Suspicious jump in case number:** an issue would be created when a large jump in case numbers appears, and updates in the sub-region would be temporarily suspended (typically for 2 to 6 hours) to allow for potential subsequent corrections in official data.

• **Decrease in accumulated numbers:** most number decreases would be considered as history corrections. When this happens, if the full official historical data is accessible, we update the dataset according to the most recent official time series. In systems where only the current statistics is available, we adjust the most recent historical case data to maintain the non-decreasing property of each time series.

In a nutshell, continuous update mechanism is instrumental in reducing noise in the CovidNet dataset. We also implemented daily-scheduled checks and cross validations with official and other independent platforms. Many of the noises have been identified and corrected thanks to the manual efforts of our volunteer team.

5.3 Quality Control in a Decentralized Volunteer Team

Unlike many other platforms, the CovidNet project has been conducted by a fully decentralized volunteer team. This presents a unique challenge to the data control quality.

**Repeated entry of the same data** In the decentralized team, multiple volunteers might be working on the same update (overlapping work), or failing to recognize existing duplicated records (duplicated records).

To prevent overlapping work, our volunteers will first check potentially related open updates before their own updates. Duplicated records was prominent in the early stage of CovidNet project when we used ET format. If accumulated numbers were available in the reports, the volunteer would directly check the total number in the specific area, and prevent duplicated cases. If accumulated numbers were unavailable, the volunteer would check within all existing records, especially case-clusters sharing the similar attributes as described in the report, and leave out duplicated reports.

**Uncoordinated Deployment** All volunteers can deploy data updates to the front-end website. This was designed earlier to avoid delayed data presentation to the public. However, when one attempts to deploy a correctly completed number change, other members might be in the middle of updating and validating case information in a different region. For instance, on April 15, 2020, when a volunteer attempted to modify the confirmed number in Okaloosa, Texas from 102 to 103, the data entry experienced a transit state as "102103", which was quickly corrected by the volunteer. However, during the short transit stage, there happened to be a website deployment, which resulted in an abrupt number jump by more than 100000, and then got corrected within minutes after the subsequent deployment.

These type of issues are not typical "data errors", but due to the decentralized deployment setup, which is, however, necessary to prevent delayed website presentations. To minimize disadvantages associated with, we gradually constructed a list of rules that would be automatically checked before each deployment. Any deployment would be forbidden (unless being manually interfered), if one of the following criteria is triggered:

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19El portal web de Datos Abiertos del Ministerio de TecnologAñas de la InformaciAñas y las Comunicaciones: https://www.datos.gov.co/en/Salud-y-Protecci-n-Social/Casos-positivos-de-COVID-19-en-Colombia/gt2j-8ykr/data
20Department of Health Data Drop https://ncovtracker.doh.gov.ph/
18The definition of jump is determined empirically in practice. For example, a number change larger than 3 times would be defined as a jump, given that the initial value is larger than 100.

19A large decrease might be an error, and falls into the jump category described earlier.
20A longer time-series may require modification in practice. This may not be optimal but the ideal solution requires data we have no access to.
21This accidental jump then appeared rapidly also on other platforms [4, 10] and media reports.
We offer several ways for users to compare the COVID-19 trends. We have implemented the Analytic trend charts which shows the statistics worldwide and each single country, we present a detailed epidemic map where all thresholds applied above are deduced empirically.

The time series of case data, often referred to as epidemic curve, helps general public to understand the full history and the current stage of the COVID-19 pandemic. Our project includes both basic trends charts with plain numbers and burn-down charts which provide further insights into the varying condition. Users can explore these epidemic curves for all sub-divisions in our dataset.

Basic trend charts We provide basic trend charts at daily resolution for the following type of statistics: confirmed cases, deceased cases, positive/negative testing cases, positive testing rates, and hospitalized cases. For both confirmed and deceased curves, users can choose to view them in either linear or logarithm scale. For example, Figure 2 shows the cumulative and daily new confirmed cases worldwide.

Analytic trend charts We have implemented the burn down chart to show simultaneously the trends of active cases and recovered/deceased cases, which provides a clearer picture about the local progress over time (see Figure 4).

We offer several ways for users to compare the COVID-19 trends across different countries and sub-divisions over the whole period. One such example were shown in Figure 5. User can choose the set of countries or sub-divisions they are interested in. In addition to static plots, we make available several animations on our project website to show the evolution of the comparative statistics across different regions.

6 INTERACTIVE TOOLS FOR VISUALIZATION

6.1 Geographical Distribution of Current Cases

We briefly discuss some other platforms which are also taking their data presentations which helped us build our own system. One such example was DXY project has been among the most popular dashboards for COVID-19 information in China. They provide daily update by collecting data from all levels of official health departments, which has been quite trustful, and we have adopted their data as our source in China. Compared with the case in U.S., the data collection in China has been relatively easy and well-organized, as official channels have started a formal reporting schedule since the early stage and no extra media reports were required. We have seen the success and the impact brought by DXY’s integrated data platform, which helped local communities in China to response effectively to the outbreak. This inspired us to start our own project for North America and eventually as a global tracker. We also studied their data presentations which helped us build our own system. While their focus has been the condition in China, data in the rest part of the world is collected and presented only in country level, with a delayed update for data in U.S. due to the reason we explained earlier.

6.2 Temporal Epidemic Curves

6.3 Cross Region Comparison

(1) the number is smaller than the one from the previous day;
(2) the number of a county-level region increases more than 4000 in a single day;
(3) the daily increase is more than 300%, while the previous day’s number is larger than 10;
(4) the daily increase is more than 200%, while the previous day’s number is larger than 50;
(5) the daily increase is more than 50%, while the previous day’s number is larger than 1000;

where all thresholds applied above are deduced empirically.

7 ACCESSING COVIDNET DATASET

We would grant open access to CovidNet for any non-commercial use. The dataset is accessible by filling a data request form at https://airtable.com/shrMqS4C6wjpZLCP0, before which the user should have read carefully about terms of data usage at https://coronavirus.1point3acres.com/en/data. We do prohibit crawling, scraping, caching or otherwise accessing any content on the platform via any automated means, due to the expensive bandwidth consumption which has brought a huge financial burden on the project. To continue providing timely information to the general public, we welcome only fair access to our dataset and other contents.

8 RELATED WORK

To continue providing timely information to the general public, we welcome only fair access to our dataset and other contents.
**John Hopkins COVID-19 Dashboard** [4]. A previous paper [4] described the effort of a team from John Hopkins University in a global COVID-19 data platform which consumes dataset provided by DXY in China and later ours in U.S for a global visualization. As a completely independent data-collection source, our North America dataset has been continuously used by [4] as one of their sources in the county-level breakdown data in the U.S. area. Unlike our close to real-time update, there has been a delay of U.S. data on the JHU Dashboard (1 or more days) since the end of April. Last but not least, similar as DXY, worldwide data is only provided at country level on the JHU Dashboard.

**Worldmeter COVID-19 Tracker** [10]. This is another COVID-19 tracker which offers partial regional breakdown in U.S. while providing country-level numbers in the rest of the world. For several states in U.S. [24], Worldmeter updates information in real-time which has been more up-to-date than the JHU Dashboard.

**Other related projects.** The COVID Tracking Project [1] has collected and provided data in testing, hospitalization, and, very recently, the demographic distribution in different states in U.S. We have been using their data for both testing and hospitalization visualizations, which provide an enriched description about local epidemic conditions especially when the testing does not widely cover the local community. The DriveThruLocation [1] is another valuable project which collects detailed information on locations providing drive-through COVID-19 testing services in U.S. While not closely related to the pure data practice, we have collaborated with this project team as testing information is vital for local communities, which fits our purpose of serving the public in general.

### DISCUSSION

This paper delivers a detailed introduction about the 1Point3Acres CovidNet project, elaborating both the data collection process and the quality control mechanism.

We would like to share some lessons we have learnt from the project. The real time nature and the exhaustive geographical distribution of CovidNet have attracted a large number of users on the platform. While we have been trying our best to provide a creditable data integration, our practice has also suggested the necessity of constructing an official information integration pipeline to confront potential public health challenges, especially in the current era when human interaction has become an essential component of the modern society. At the same time, as inter-national connections have been much stronger than any previous time, global level pandemic information sharing would be of vital importance in both learning from experiences of other countries and assessing a local public health risk level according to interactions among different countries and regions. On the other hand, when more public challenges have upgraded to the global level, we have also seen the strength of data driven approaches in tackling large scale problems.

With real time update of sub-division level COVID-19 information across more than 27 countries, the CovidNet dataset could benefit everyone in various ways. For general public, the analytic trend charts have provided more intuitive descriptions about the local epidemic situation, and would help local communities to make decisions about working and traveling. For local governors, a comparison with situations and trends in other states/counties would be instructive for evaluating different policy scenarios, including restrictive orders and economy reopening. For academic community, the CovidNet dataset could lead to researches in diverse potential directions: time series data could be combined with conventional epidemiological models to make prediction about the near future; the sub-division breakdown has provided detailed geographical distribution of COVID-19 outbreaks and may be used to analyze the impact of different external factors associated with each local region, e.g., weather, economy, population, industries, races, restrictive-order levels, and so on; the worldwide dataset together with information on inter-national activities offers the potential to study the global spreading behavior of the disease.

We welcome and encourage users from all industries utilizing the CovidNet to assist the battle against COVID-19. We especially look forward to more insights offered from academic researches by investigating the rich dataset provided by CovidNet project.

### DISCLAIMER

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Table 2: List of official worldwide data source

| Country          | subdivision | Information Source                                                      | Available Data                              |
|------------------|-------------|-------------------------------------------------------------------------|---------------------------------------------|
| Austria          | Bundesland  | Bundesministerium für Soziales, Gesundheit, Pflege und Konsumentschutz | confirmed, deceased, recovered              |
| Belgium          | Region/ Province | Sciensano, the Belgian Institute for Health | confirmed, deceased, recovered              |
| Switzerland      | Canton (States) | Zurich Statistisches Amt | confirmed, deceased, recovered              |
| Chile            | Region (Province) | Ministerio de Salud | recovered at country level                  |
| Germany          | Stadtstaaten/ Flächenänder | Robert Koch Institute | recovered info not available                |
| Spain            | Autonomous Communities | Instituto de Salud Carlos III | confirmed, deceased, recovered              |
| United Kingdom   | Upper Tier Local Authorities | National Health Service | confirmed, deceased, recovered              |
| India            | States/ Territories | Ministry of Health | confirmed, deceased, recovered              |
| Italy            | Region        | Presidenza del Consiglio dei Ministri | confirmed, deceased, recovered              |
| Japan            | To/ DAJ/ Ken/ Fu | Ministry of Health, Labour and Welfare | confirmed, deceased, recovered              |
| South Korean     | Do/ Jachido   | Korean CDC, & Ministry of Health and Welfare | confirmed, deceased, recovered              |
| Malaysia         | States/ Territories | Director General of Health Malaysia | confirmed, deceased, recovered              |
| Netherlands      | Province      | Rijksinstituut voor Volksgezondheid en Milieu Ministerie van Volksgezondheid, Welzijn en Sport | deceased and recovered reported at country level |
| South Africa     | Province      | Nation Institute for Communicable Diseases | confirmed, deceased, recovered              |
| Russian Federation | Federal Subjects | Federal Service Human Well Being | confirmed, deceased, recovered              |
| Saudi Arabia     | Governorates  | King Abdullah Petroleum Studies and Research Center | confirmed, deceased, recovered              |
| Sweden           | Landsting     | Folkhälsoomnämnden | confirmed and recovered                      |
| Mexico           | State         | Gobierno De Mexico | confirmed and deceased                      |
| Peru             | Departamentos | Ministerio de Salud | confirmed and deceased                      |
| Brazil           | State/ Federal District | Ministério da Saúde | confirmed, deceased, recovered              |
| Portugal         | Região/Açô | Ministério da Saúde | confirmed, deceased, recovered              |
| Pakistan         | Province      | Ministry of National Health Services | confirmed, deceased, recovered              |
| France           | Régions/ Régions d’outremer | Sante Publique France | confirmed, deceased, recovered              |
| Ecuador          | Region        | Ministerio de Salud | confirmed, deceased, recovered              |
| Indonesia        | Provinsi      | Graha Badan Nasional Penanggulangan Bencana | confirmed, deceased, recovered              |
| Philippine       | Region        | Department of Health Datadrop | confirmed, deceased, recovered              |
| Liechtenstein    | Country       | Zurich Statistisches Amt | confirmed, deceased, recovered              |
| China            | Province/ SARs| DXY tracker | confirmed, deceased, recovered              |
| United States    | States        | 1point3acres tracker | confirmed, deceased, recovered              |
| Canada           | States        | 1point3acres tracker | confirmed, deceased, recovered              |