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Using analytics to support a utility's initial response to the COVID-19 pandemic amid an uncertain evidence base

Received (in revised form): 15th September, 2020

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Journal of Business Continuity
& Emergency Planning
Vol. 14, No. 3, pp. 226–238

1749–9216

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Abstract

Energy utilities play a critical role in fostering disaster resilience. Much of the world is increasingly dependent on the availability and reliability of safe and efficient energy. In addition to its importance for industrial, commercial and household functionality, energy provision is increasingly significant in determining health and equity outcomes during a disaster. Amid the COVID-19 pandemic, issues of workforce protection and absenteeism are critical for public safety as well as for the continuity of operations for utilities and the businesses that rely upon them. However, COVID-19, and pandemics generally, have rapidly evolving and imperfect evidence available to support rapid and real-time decision making. This article reflects the initial setup and operations of frameworks utilising analytics to support decision making from March through July 2020 for a major US electric utility. These initial strategies have enhanced decision making and provided a foundation for additional integration of the evidence base and use of analytics for anticipated decision support in the coming phases of the COVID-19 pandemic, as well as for future pandemics of unknown aetiology.

Keywords: COVID-19, pandemic, decision support, utilities, electricity, absenteeism, modelling

BACKGROUND

Around December 2019 a novel coronavirus, later named COVID-19, likely emerged from a live animal and wet market in Wuhan, China, and began spreading among the community.[1,2] Early warnings of the dangers of this highly virulent coronavirus were missed, and the virus quickly spread around the globe. By 24th July, 2020 there had been more than 15 million cases documented in 188 countries.[3] The true case counts, however, are unknown due to inadequate testing, reporting and contact tracing. The result is an undercount of mild infections and an unknown but not nominal number of asymptomatic infections.[4]

As of the same date, more than 165 vaccines were under development, with 27 in some form of human trial. In addition to this, nearly 300 treatments were undergoing various trials, including some showing promising results. As of this writing, however, none are yet available as a pharmaceutical means of reducing transmission in the community, or substantially reducing morbidity and mortality at a population level.[5,6] Testing capacities in the USA have improved; but widespread rapid point-of-care testing is still not reliably available, and serology testing for immune response is limited and with uncertain reliability because of many unknowns regarding the duration and level of immune response from prior COVID-19 infection.

Energy utilities play a critical role in fostering disaster resilience and are considered to be among the disaster community lifelines by the US Federal Emergency Management Agency.[7] This is for good reason: the USA (indeed, the world) is increasingly dependent on the availability and reliability of safe and efficient energy. In addition to its importance for industrial, commercial and household functionality, energy provision is increasingly significant in determining health and equity outcomes during a disaster.[8]

The COVID-19 pandemic is no exception to the importance of this essential lifeline. With more than one-third of the workforce estimated to be working remotely, and most schools shifting to remote learning strategies, power and connectivity at home have become more essential than ever.[9,10] However, simply keeping the lights on is also more challenging. Changes to load distribution due to significant shifts in usage patterns create new dynamics and stressors for utilities to manage.[11] On top of this, the personnel who work at utilities are not immune to the pandemic. Issues of workforce protection are critical for public safety as well as for continuity of operations for utilities and the businesses that rely upon them.[12]

In 2019, Commonwealth Edison (ComEd), the electric utility serving more than 4 million customers in Chicago and northern Illinois, partnered with the National Center for Disaster Preparedness (NCDP) at Columbia University's Earth Institute to further the development of lessons and best practices for utilities in supporting disaster resilience. In March 2020, this relationship was expanded for NCDP to provide technical assistance in developing research analytics for operational and strategic decision support for ComEd in response to the COVID-19 pandemic.

ComEd took swift action in mid-March when the pandemic became a severe threat in its service territory, transitioning its remote capable employees to working from offsite locations even before the State of Illinois implemented a stay-at-home order. However, a significant portion of ComEd's workforce is composed of essential workers who must report to onsite locations to operate and maintain the electric grid. At the time, the dynamics of virus transmission were less well understood than they are now, and ComEd was looking to develop analytical tools that would inform efforts to protect its workforce and maintain critical operations.

This article reflects the initial setup and operations of frameworks utilising analytics to support decision making from March through July 2020. These frameworks continue to evolve as additional scientific information and pharmaceutical advancements become available to support ongoing response efforts.

APPROACH

Primary considerations for pandemic decision support at ComEd were, and continue to be, to ensure the health and safety of the workforce while minimising COVID-19 related absenteeism and disruption to essential operations. The analytics outputs discussed below draw from research, methods and case studies from diverse literature encompassing epidemiology, virology, disaster risk reduction, vulnerability and resilience, public policy, and business and organisational management. The analytic tools that were developed draw from such diverse sources to provide optimal support balancing protective actions with desired outputs considering each decision's many uncertainties and variables both internal and external to ComEd.

The analytical decision support approach was based on a series of grounding principles and assumptions. The first assumption

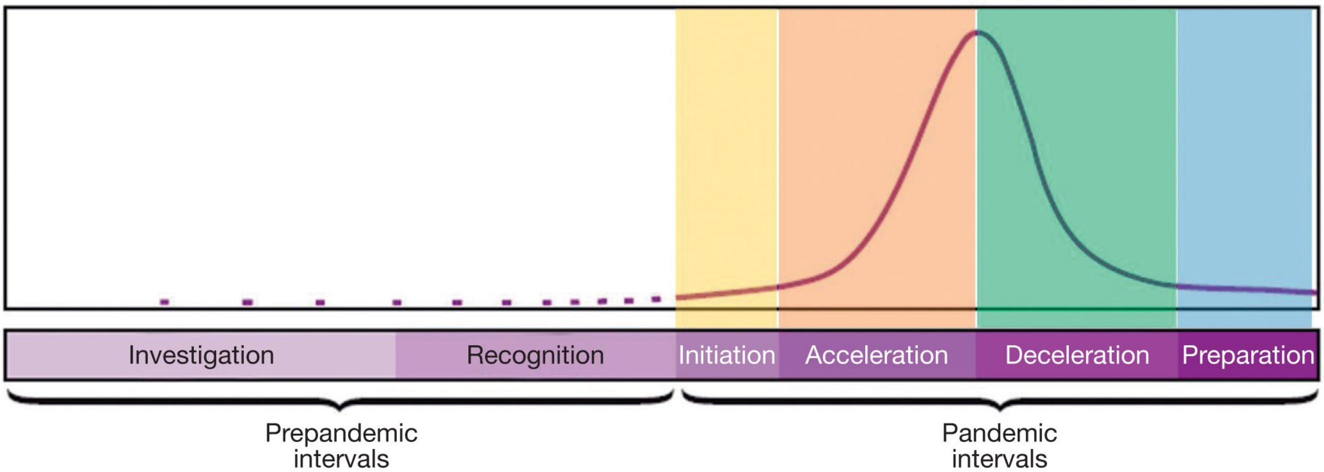


Figure 1: Pandemic intervals, as defined by the Centers for Disease Control and Prevention

Adapted from: Holloway R., Rasmussen S. A., Zaza S., Cox N. J., Jernigan D. B. and the Influenza Pandemic Framework Workgroup (2014) 'Updated preparedness and response framework for influenza pandemics', *Morbidity and Mortality Weekly Report: Recommendations and Reports*, Vol. 63, No. 6, pp. 1–18.

was that the COVID-19 pandemic would roughly follow the four pandemic intervals of initiation defined by the US Centers for Disease Control and Prevention, namely, acceleration, deceleration and preparation, with the likelihood of multiple waves of infection over a period of months to years[13] (see Figure 1).

The second assumption was that different interventions would be required to be implemented and relaxed throughout the pandemic based on the apparent interval, as well on local/regional epidemiology and emerging research on the transmissibility and susceptibility of the virus. Those interventions may correspond to pandemic waves or may otherwise need to be adapted due to local and regional transmission dynamics.

The third assumption was that potential interventions can be grouped based on their relative efficacy and level of disruption to operations. These generic groupings serve as a starting point for consideration. However, different job functions will have different levels of relative risk, and the operational impact from each intervention may vary based on job function. Some staff, such as those in the field, have a very different risk environment from those in an office setting; and certain functions are easier to accommodate with remote work than others. The intervention groupings in Figure 2 are therefore expected to vary both based on pandemic conditions as well as by job function.[14] These interventions are neither definitive nor exhaustive, and may evolve as new research, technologies and/or pharmaceutical interventions become available. Figure 3 shows how the layering of interventions could be considered during a pandemic wave.[15]

The foundational decision support framework is rooted in the principles reflected in the synchronisation matrix approach. This approach drives information management based on a phased approach to decision making, in which each phase is described in a two-tier synchronisation matrix with decision inputs in the top tier and actionable outputs in the bottom. Information collection and analysis is centred on supporting key decisions and the actions that are driven by these decisions. The information

Easier to Implement

Group	Strategy	Strategy Description	Costs
Group A	**Personal Hygiene**	Hand washing/sanitizing, respiratory etiquette, etc.	Supplies and information
Group A	**Self-Diagnosis**	Checklist of symptoms to consider before leaving home	Criteria development, addtl sick time
Group A	**Workplace Cleaning**	Increased cleaning/sanitizing of offices	Cleaning services and supplies
Group A	**Travel Restrictions**	Restrict non-essential travel, and higher risk travel	Opportunity and productivity
Group B	**Wellness Screening**	Temperature and symptom screening upon entry	Screening staff, supplies, admin
Group B	**PPE / Masks**	Mandated use of masks and other PPE (e.g. face shields, gloves)	PPE purchase, distribution, admin
Group B	**Distancing (Onsite)**	Stagger shifts and breaks. Restrict in person meetings & gatherings	Administration and productivity
Group B	**Telework**	Transition positions to telework	Software, hardware and admin
Group B	**Travel Suspension**	Suspend non-critical travel, strict safety protocols	Opportunity and productivity
Group C	**Workplace Redesign**	Spacing, physical barriers, air flow /filtration, etc.	Equipment and capital costs
Group C	**Testing / Tracing**	Periodic testing of staff	Staff, supplies, run costs, admin
Group C	**Daily Testing**	Regular, rapid testing prior to entry (most effective)	Staff, supplies, run costs, admin
Group C	**Sequestration**	Sequester critical staff in low risk environment	Accommodations, psychological

Harder to Implement

Figure 2: Potential policies to reduce infection

Adapted from: Massachusetts High Technology Council (2020) 'COVID-19 Back-to-Work Planning Briefing', available at: http://www.mhtc.org/wp-content/uploads/2020/04/MHTC-COVID-19-Briefing-5.1.20.pdf (accessed 5th November, 2020).

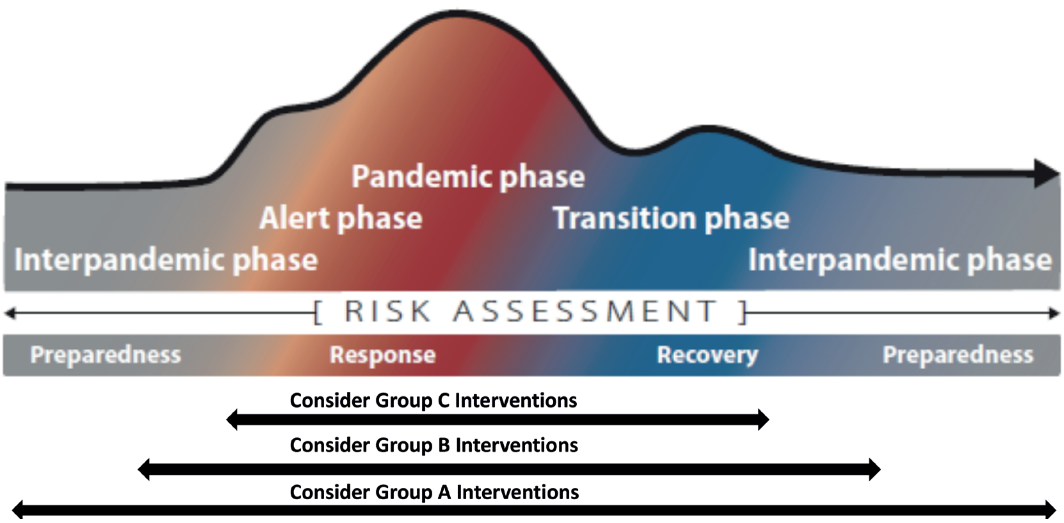


Figure 3: Notional layering of interventions

Adapted from: Centers for Disease Control and Prevention (2016) 'The Continuum of Pandemic Phases — 508', available at: https://www.cdc.gov/flu/pandemic-resources/planning-preparedness/global-planning-508.html (accessed 24th July, 2020).

Coronavirus Pandemic (COVID-19)

PHASE: ACCELERATION / RE-ACCELERATION

INFORMATION NEEDED

DECISIONS NECESSARY	THREAT INFORMATION	CONTEXT

• ***Implement*** Group A Interventions as necessary
• ***Implement*** Group B Interventions as appropriate
• ***Initiate*** Group C Interventions as appropriate
• ***Identify*** additional interventions that may be necessary
	• **What is the severity of the virus (e.g. hospitalization and fatality rates)?**
	• **What is the current rate and trend of transmission in the area?**
	• **What is the rate of transmission for the virus?**
	  ◦ **What is it forecasted to peak?**
	• **What is the attack rate/likelihood of infection?**
	• **What is the average duration of the illness?**
	  ◦ **What is the duration for more serious cases?**
		• What social distancing measures are in place by local/state governments?
		  ◦ **How effective is it? For how long as this trend held?**
		• What are the measures implemented in surrounding areas?
		• How long have control measures been in place?
		  ◦ **How long are they expected to be in place?**
		• What is the capacity/reliability of testing?
		• What is the availability of personal protective equipment?
		• What is the availability of pharmaceutical countermeasures?

ACTION NEEDED

LEADERSHIP COORDINATION	ANALYTICAL SUPPORT

• Monitor absenteeism among all staff with particular attention to essential functions
• Implement additional interventions as appropriate
• Cross-train staff for re-assignment if necessary
  ◦ Re-assign staff to essential functions as needed
• Identify operations at high risk for infection; and mitigation strategies
• Monitor changes in electricity loads due to changing consumer patterns
• Monitor/modify distribution operations to meet changes in consumer demand
• Modify distribution operations for increased resilience in the event of worker absenteeism
• Enhance employee communications and resources to support health and mental health at work and home
	• Update/Calibrate model(s) regularly to:
	  ◦ Analyze current epidemiological curve(s) amd project rates of increase and potential peaks
	  ◦ Evaluate ComEd absenteeism and illness relative to community-wide spread
	• Monitor absenteeism for trends and clusters of potential infection
	• Model transmission scenarios (no change, significant reduction, significant increase, etc)
	  ◦ Utilize available epidemiological research to inform scenario development
	• Recommend additional interventions based on epidemiological analysis
	• Where possible, analyze risk for certain job functions (e.g. Travel)

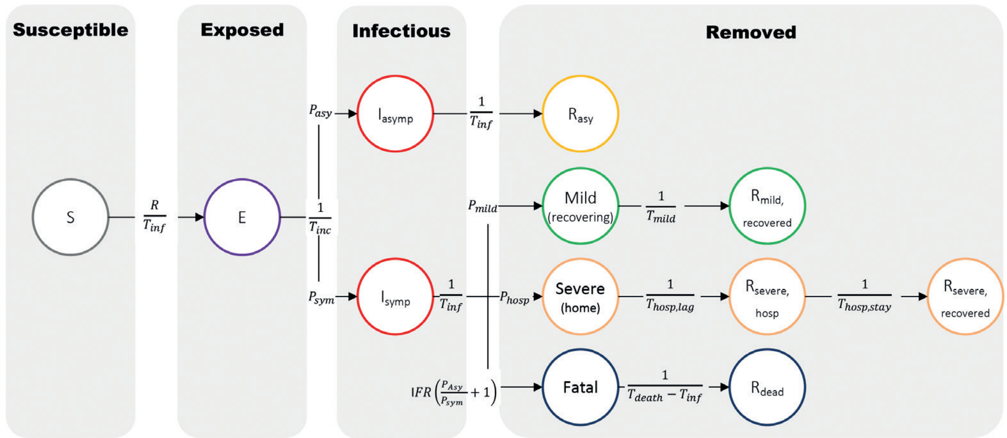
Figure 4: Example synchronisation matrix: Acceleration phase

inputs are then optimised in supporting these decisions and are categorised as threat information and contextual information. Threat information is the information about the threat itself, and in this case was the evolving epidemiology of the COVID-19 pandemic. Contextual information (sometimes referred to as 'critical information'), is based on the actions and the situation of external stakeholders that could influence decisions (eg what restrictions are in place, are neighbouring jurisdictions altering their approach, etc)[16] — see Figure 4 (bolded items are information requirements that analytics can support).

MODELLING IMPACTS TO INFORM DECISION MAKING

A mathematical model based on the susceptible, exposed, infectious, removed (SEIR) framework was developed by ComEd to provide ongoing decision support (see Figure 5). The meta-model was built based on the work of Gayane Poghotanyan and the system of equations started from the work of Gabriel Goh.[17,18] As ComEd's workforce is too small for ComEd to run the model, the model projects COVID-19 related absenteeism for the ComEd workforce based on COVID-19 case projections for five counties in northern Illinois, including Cook, Lake, DuPage, Kane and Will, through an additional simplified meta-population model. As of 1st July, 2020, these counties accounted for nearly 80 per cent of Illinois' population and 95 per cent of its positive COVID-19 cases (see Figure 6). The majority of ComEd's workforce resides and works in those counties.

The pandemic model is continuously tuned and utilised to project COVID-19 related absenteeism over time for a range



- The graphic model demonstrates the transition between stages where individuals are:
  - Susceptible,
  - Exposed,
  - Infectious, and
  - Removed.
- The system of differential equations describes:
  - The mathematical relationship between those who are susceptible to an infection and those who get exposed,
  - The mathematical relationship between exposed individuals and those infected, and infected individuals and those who recover from the illness

$$\frac{dS}{dt} = -(\beta_{\text{symp}} * I_{\text{symp}} + \beta_{\text{asymp}} * I_{\text{asymp}}) * S/N$$

$$\frac{dE}{dt} = (\beta_{\text{symp}} * I_{\text{symp}} + \beta_{\text{asymp}} * I_{\text{asymp}}) * S/N - \sigma * E$$

$$\frac{dI_{\text{symp}}}{dt} = \sigma * (1 - P_{\text{asymptomatic}}) * E - \gamma * I_{\text{symp}}$$

$$\frac{dI_{\text{asymp}}}{dt} = \sigma * P_{\text{asymptomatic}} * E - \gamma_{asymp} * I_{asymp}$$

$$\frac{dR_{\text{asymp}}}{dt} = \gamma_{\text{asymp}} * I_{\text{asymp}}$$

$$\frac{d\text{Mild}}{dt} = p_{\text{mild}} * \gamma * I_{\text{symp}} - \frac{1}{T_{\text{mild}}} * \text{Mild}$$

$$\frac{d\text{Severe}}{dt} = P_{\text{hospitalized}} * \gamma * I_{\text{symp}} - \frac{1}{T_{\text{hlag}}} * \text{Severe}$$

$$\frac{d\text{Severe}_{\text{H}}}{dt} = \frac{1}{T_{\text{hlag}}} * \text{Severe} - \frac{1}{T_{\text{hospital}}} * \text{Severe}_{\text{H}}$$

$$\frac{d\text{Fatal}}{dt} = p_{\text{fatal}} * \gamma * I_{\text{symp}} - \frac{1}{T_{\text{death}} - T_{\text{inf}}} * \text{Fatal}$$

$$\frac{dR_{Mild}}{dt} = \frac{1}{T_{\text{mild}}} * \text{Mild}$$

$$\frac{dR_{\text{Severe}}}{dt} = \frac{1}{T_{\text{hospital}}} * \text{Severe}_{\text{H}}$$

$$\frac{dR_{\text{Fatal}}}{dt} = \frac{1}{T_{\text{death}} - T_{\text{inf}}} * \text{Fatal}$$

Figure 5: The framework of the ComEd SEIR model

of user-specified scenarios. Model input parameters are closely monitored and updated biweekly by the research team based on curated research of current medical and epidemiological literature and daily by the modelling team during tuning as required by the latest developments.

Additionally, scenarios were developed to reflect three potential trajectories of work absenteeism as a result of external policy changes: one where there is no change to the current transmission trajectory; a second where there is a slight increase in transmission; and a third where there is a significant increase in transmission. These scenarios are updated based on recent ComEd data and as conditions warrant (eg when the State of Illinois is considering relaxing restrictions).

KEEPING UP WITH A DYNAMIC EVIDENCE BASE

As with any emerging threat, the initial evidence from public sources was scant and shifting. Establishing a consensus among the available data was problematic: early data were not always collected or presented with comparable methodologies, or ideal experimental design for drawing broader conclusions. As there are sociological, political, ecological and biological characteristics of disease transmission, data from one outbreak may not adequately predict the impact elsewhere.[19,20] However, response efforts can be framed in a manner that does not require precision in the data to justify implementation, and some degree of uncertainty can be tolerated if an intervention is presumed to provide a measure of protection, even if one cannot yet quantify its effectiveness (eg the precise efficacy of social distancing versus a general consensus among the data that it is effective).

In order to create a process of grounding intervention discussions and data analysis in the latest available scientific information, while acknowledging that new data, insights and discoveries are emerging

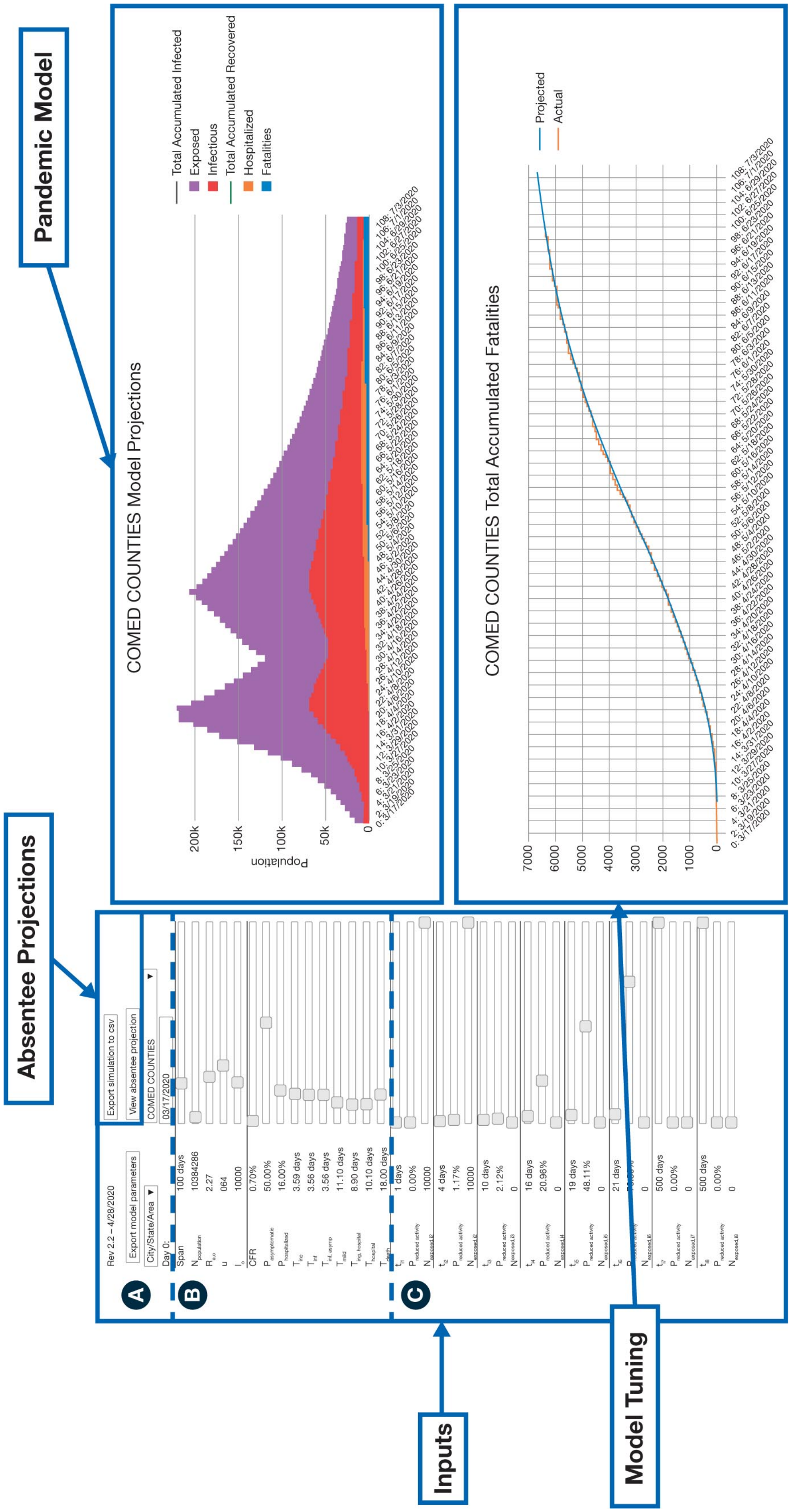
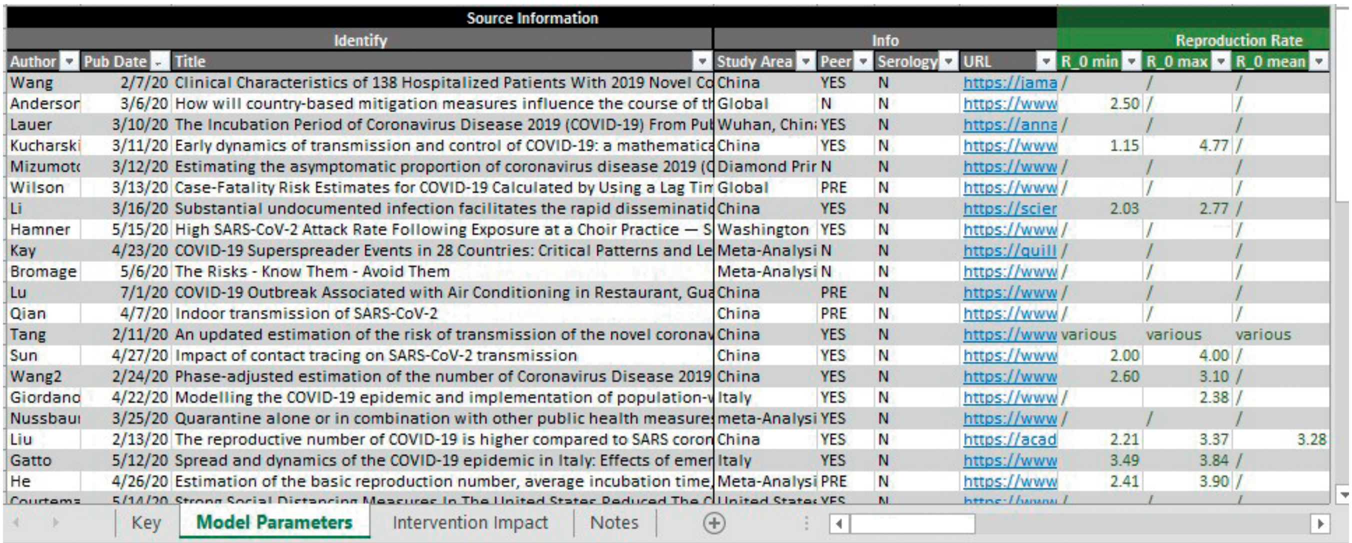


Figure 6: Simplified meta-model for ComEd



Source Information									
Identify			Info				Reproduction Rate		
Author	Pub Date	Title	Study Area	Peer	Serology	URL	R_0 min	R_0 max	R_0 mean
Wang	2/7/20	Clinical Characteristics of 138 Hospitalized Patients With 2019 Novel Co	China	YES	N	https://jama	/	/	/
Andersor	3/6/20	How will country-based mitigation measures influence the course of th	Global	N	N	https://www	2.50	/	/
Lauer	3/10/20	The Incubation Period of Coronavirus Disease 2019 (COVID-19) From Pul	Wuhan, Chin:	YES	N	https://anna	/	/	/
Kucharski	3/11/20	Early dynamics of transmission and control of COVID-19: a mathematica	China	YES	N	https://www	1.15	4.77	/
Mizumoto	3/12/20	Estimating the asymptomatic proportion of coronavirus disease 2019 (C	Diamond Prir	N	N	https://www	/	/	/
Wilson	3/13/20	Case-Fatality Risk Estimates for COVID-19 Calculated by Using a Lag Tim	Global	PRE	N	https://www	/	/	/
Li	3/16/20	Substantial undocumented infection facilitates the rapid disseminatic	China	YES	N	https://scier	2.03	2.77	/
Hamner	5/15/20	High SARS-CoV-2 Attack Rate Following Exposure at a Choir Practice — S	Washington	YES	N	https://www	/	/	/
Kay	4/23/20	COVID-19 Superspreader Events in 28 Countries: Critical Patterns and Le	Meta-Analysi	N	N	https://quill	/	/	/
Bromage	5/6/20	The Risks - Know Them - Avoid Them	Meta-Analysi	N	N	https://www	/	/	/
Lu	7/1/20	COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Gua	China	PRE	N	https://www	/	/	/
Qian	4/7/20	Indoor transmission of SARS-CoV-2	China	PRE	N	https://www	/	/	/
Tang	2/11/20	An updated estimation of the risk of transmission of the novel corona	China	YES	N	https://www	various	various	various
Sun	4/27/20	Impact of contact tracing on SARS-CoV-2 transmission	China	YES	N	https://www	2.00	4.00	/
Wang2	2/24/20	Phase-adjusted estimation of the number of Coronavirus Disease 2019	China	YES	N	https://www	2.60	3.10	/
Giordano	4/22/20	Modelling the COVID-19 epidemic and implementation of population-w	Italy	YES	N	https://www	/	2.38	/
Nussbau	3/25/20	Quarantine alone or in combination with other public health measure:	meta-Analysi	YES	N	https://www	/	/	/
Liu	2/13/20	The reproductive number of COVID-19 is higher compared to SARS coron	China	YES	N	https://acad	2.21	3.37	3.28
Gatto	5/12/20	Spread and dynamics of the COVID-19 epidemic in Italy: Effects of emer	Italy	YES	N	https://www	3.49	3.84	/
He	4/26/20	Estimation of the basic reproduction number, average incubation time,	Meta-Analysi	PRE	N	https://www	2.41	3.90	/
Courtema	5/14/20	Strong Social Distancing Measures In The United States Reduced The C	United State:	YES	N	https://www	/	/	/

Figure 7: Select dashboard snapshot

regularly, a process of harvesting and translating research into a dashboard was implemented. This research dashboard was created by conducting an ongoing literature review of publications that included peer-reviewed, pre-peer reviewed, official guidance and non-peer reviewed information (eg data journalism, scientific blog posts), and building a rudimentary database in Microsoft Excel.

The dashboard provides an overview of the virus transmission parameters (reproductive rate, effective reproductive rate, asymptomatic case estimates), illness recovery parameters (days to recovery for mild and severe cases), hospitalisation parameters (hospitalisation rate, days from onset to hospitalisation, days in hospital), and fatality information (case fatality rate, days from onset to death). Research parameters such as sample size, data source, methodology and country of origin were also included in the dashboard to provide a subjective measure of fidelity and context for each study. The dashboard approach for collecting all model parameters is beneficial because it provides the user with an at-a-glance overview of the general consensus across measures, while maintaining the ability to drill down into specific geographic areas or particular studies (see Figure 7).

The dashboard also includes additional components with information on alternative models for comparison with ComEd's SEIR model (eg what assumptions and methods may drive different outputs), as well as emerging return-to-work guidance from official and industry sources, datasets to support return-to-work analysis, and region-specific updates. These alternative models have been developed by organisations globally and nationally and allow for a comparative view on how these institutions are projecting the impact of COVID-19 on various demographics and scales.

With regards to preparing the workplace for employees to return, there were key commonalities among the different resources, including: an increase in outdoor air ventilation, controlled flow of ingress and egress from shared spaces, leveraging virtual/digital productivity tools wherever possible, and prescribing the use of cloth masks at onsite locations. Additional use of personal protective equipment may also be considered to further mitigate risks. In general, while model and parameter literature was heavily academic, the return-to-work literature draws heavily from grey (non-peer reviewed) literature and operational guidance documents.

PRELIMINARY FINDINGS

As of 1st July, 2020, ComEd's efforts to mitigate the impact of COVID-19 on its workforce appeared to have been effective. Initially, ComEd employees had a higher cumulative positive case rate per capita than the general population in corresponding northern Illinois counties. Since then, the rate of infections among ComEd employees has remained below the northern Illinois rate. This may be partially attributed to ComEd's response to the outbreak, which included remote work, strict social distancing and personal protective equipment use for employees who continued to report to onsite locations. Further validation on the precise impact of ComEd actions in reducing employee absenteeism, as well as evaluation of competing hypotheses and of potential data confounders is needed to definitively ascribe the degree of value to ComEd's efforts.

The use of analytics for decision support has been an invaluable tool for making data-driven decisions, despite limitations in the availability of existing data and the dynamic and uncertain nature of the pandemic. The primary analytical inputs to support decision making have focused on understanding and maintaining awareness concerning: transmission and prevalence of COVID-19 in the community, the trajectory of transmission (increasing or decreasing), disease transmission characteristics (eg where are outbreaks occurring, under what conditions), and the anticipated duration of the pandemic wave.

Although the parameter dashboard cannot provide concrete average rates for parameter values, it has allowed researchers from both NCDP and ComEd to weigh the fidelity and context of each new source, thus expediting the process of including changes into the model. In addition, tracking the values over time has allowed for the teams to observe the decreasing variance between study parameter values, increasing confidence in the chosen parameter values input into the SEIR model. Updating the alternative model dashboard showed that the models generally followed similar patterns in their outputs, with some variation based on the specific demographics, interventions and variance in modelling methodologies. Common intervention assumptions gleaned from these comparative models include the impact of strong social distancing policies in place for an extended period and the dynamic tendency of the transmission rate.

The return-to-work datasets aim to provide an overview of factors that may impact worker absenteeism not related to the physical health of ComEd's employees. Potential contributors to absenteeism for employees who would need to be physically present include the continued closure of schools and household income (eg if schools remain closed while workplaces start to open, parents who are unable to afford childcare might have to sacrifice work in order to stay home for their children). Additionally, if Illinois limits the use of public transportation, specifically in the Chicago metropolitan area, this may impact ComEd employees who rely on public transportation to get to work. Quality-of-life indicators related to mental health might impact worker absenteeism both positively and negatively as these may create additional stressors that are synergistic with the challenges presented from COVID-19 as well as returning to work amid potential ongoing uncertainty regarding the COVID-19 pandemic.

NEXT STEPS

Additional decision support tools for the relaxation as well as the implementation/re-implementation of control measures — as required by contemporaneous conditions — are under development, and existing approaches are being refined as new evidence emerges.

As additional information becomes available, specific interventions are reevaluated based on sub-factors for risk. In the case of travel restrictions, for example, reassessment includes consideration of alterations to official government travel guidance as well as viral transmission and infection rates in the departing and arriving regions. As technologies improve for rapid point-of-care testing and contact tracing, these interventions paired with job function analysis may emerge as a feasible means for reducing transmission when remote work is not an option.

Decisions for return to work will similarly be informed by a growing base of evidence for different aspects of workplace dynamics, including changeable transmission risks as well as research into mitigation strategies. This includes assessing workplace elements such as density (people/square feet), ventilation (including air filtration), respiration intensity, shared surfaces, exposure duration, traffic flow and workplace layout.

The availability of viable vaccines and treatments that reduce disease severity will likely have a profound impact on the scope of necessary complementary non-pharmaceutical interventions. As the timeline for the availability of pharmaceutical interventions remains uncertain, the analytic team can support the decision-making process through scenario-based projections, estimating various timelines for vaccines and the resultant outcomes for viral transmissibility among the worker population.

CONCLUSION

Analytics plays a vital role in supporting decision-making for utilities in their day-to-day operations. For ComEd, the COVID-19 pandemic required the development of new analytics and decision support tools with the guidance of expert partners. The information gleaned from these tools can help to frame the uncertainty of and identify the trade-offs in different intervention scenarios. In order to be effective, however, the process of collecting and analysing information must be revised and refreshed regularly, and be integrated into a decision-making process that embraces the uncertainty and shifting nature of the pandemic. Further evaluation of specific analytic approaches and inputs may help to inform and enhance permanent systems for pandemic preparedness, response and recovery.

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