Adaptt - * Surge Planning Support Tool – instructions *

This tool is an experimental surge capacity estimator for inpatient care, aiming to support policymakers in surge resources to respond to COVID-19, by simulating different parameters. Adaptt was developed by the Associação Portuguesa de Administradores Hospitalares and Glintt. As requested by the World Health Organization, both entities agreed to release it as an open source free software. All contributions to its improvement are welcome.

The tool is designed to work in MS Excel Office 365 version. Some features will not work properly in older versions.

The tool is a spreadsheet and contains nine visible sheets:

- *Language Setup (only available for editors for translation)*

- Guide: this is the entrance tab where you have the index for the other tabs

- **Surge_Predicted_Impact**: this is the main tab. It shows the graphical output of the predictions and the predicted days of shortage in surge capacity. It allows the calibration of the illustrative epidemiological model and the resources parametrization.

- SimulationResults: this tab allows the user to visualize the data used for the graphics presented on the **Surge_Predicted_Impact** tab.

- EpidemiologicalModel*Selection:* in this tab you can select the epidemiological model that you want to use.

- Custom_EpidemiologicalModel: in this tab you can input your own epidemiological model output data.

- COVID19*DailyReportedData*: in this tab you can update the real daily reported data.

- CountryPopulation: this tab has the population per country.

- Export: Data to be imported to the Health Workforce Estimator (HWFE).

Guide

This is the entrance tab where you have the index for the other tabs.

EpidemiologicalModel*Selection*

On the EpidemiologicalModelSelection tab you can choose between two models:

- SIR illustrative Model: to use a simple SIR epidemiological model[1] (developed for the tool for illustration purposes). Please check the annex 1 for the formula behind it. To use the illustrative SIR model you need to assure the following sequence of letters bellow: PRQ. P for "Column Letter with data of Daily Predicted Active Infected"; R for "Column Letter with of Daily Predicted New Infected"; and Q for "Column Letter with Cumulative Reported Infected".

Tab with **Epidemiological model to consider**	SIR_V3
Column Letter with data of Daily Predicted Active Infected	P
Column Letter with of Daily Predicted New Infected	R
Column Letter with Cumulative Reported Infected	Q

- Custom Epidemiological Model: to use your or other model results by pasting them into the "Custom_EpidemiologicalModel" tab.

    For that, select the "Custom_EpidemiologicalModel" tab and paste your daily predictive data as columns: "Daily Predicted Active Infected" and "Daily Predicted New Infected" and "Cumulative Reported Infected". Please consider t0 as the day of the first diagnosed case.

    After adding your data select "Custom_EpidemiologicalModel" on the "EpidemiologicalModel*Selection*" tab and specify the Column Letter where each data is inserted.

You can also turn visible the R_0 and the RMSE (model error with these settings vs real reported data). If on, they would be visible on the Surge_Predicted_Impact tab.

COVID19*DailyReportedData*

If you decide to use the illustrative SIR epidemiological model developed for the tool, you can introduce your daily reported data on the "*COVID19DailyReportedData*" tab. *This data will be compared with the SIR illustrative model data and give the Model RMSE (model error with these settings vs real reported data). Explained below.*

    When introducing the daily reported data, you need to consider the following parameters: *date*, *confirmed*, *confirmed_new*, *and suspected* cases.

Surge_Predicted_Impact

This is the main output/results tab. It shows the graphical results of the predictions and the predicted days of shortage. It allows the calibration of the illustrative epidemiological model and the resources parametrization.

    Parameters are grouped into seven different areas:

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[1] SIR acronym: S for the number of susceptible, I for the number of infectious, and R for the number of recovered or deceased (or immune) individuals.

a. Epidemiological model

b. COVID 19 daily update

c. Hospital activity and practices (in/out)

d. Installed capacity

e. Human Resources

f. HR capacity (to COVID inpatients)

g. HR occupational risk

Leading to results on the three graphics on the right:

- Bed capacity

- Human resources needed

- Human resources needed by skill

a. Epidemiological model

It only works if the embedded illustrative SIR model is selected (please check EpidemiologicalModelSelection). The only features that can be used for visual aid are the "Day of first reported cases", "Total days to predict" and the "Country or Region".

- Day of first reported cases – self-explanatory.

- Total days to predict – self-explanatory, you can select from 1 to 365 days.

- Country or Region - by selecting the country, it immediately displays the number of inhabitants (CountryPopulation sheet, World Bank 2020 data).

    - Consider Attack Rate - On or Off.

        - Attack Rate Scenario – It represents the percentage of the population which contracts the disease. You can select from four scenarios: Very Low (5%), Low (10%), Medium (20%) and High (30%). The different scenarios follow the reported data from China (Lower end: 5-10%) and Diamond Princess (High end: 30%).

        - Country Attack Rate – It shows the percentage of the population which contracts the disease as the scenario selected in "Attack Rate Scenario"

    - Target Population - Automatic, it varies according to the Attack rate Scenarios.

- Other Scenario Target Population - An experienced operator can introduce a different target population. If this field is used, all the model assumes this value disregarding the predefined data.

- Model RMSE (model error with these settings vs real reported data) - The RMSE is the acronym for square root of the variance of the residual showing the difference between values (sample or population values) predicted by the model and the values observed. It is an automatic parameter. This parameter is only visible if it is turned visible on the "EpidemiologicalModel*Selection*" tab.

- R_0 – The R_0 is the basic reproduction of an infection. It represents the expected number of cases directly generated by one case in a population where all individuals are susceptible to infection. It is affected by not only the characteristics of the pathogen or the disease but by other factors such as environmental conditions and the behavior of the infected population. This value is calculated for all cycle of the infection. This parameter is only visible if it is turned visible on the "Epidemiological model _*Selection*" tab.

- For illustrative purposes the tool allows the simulation of three levels of physical distancing measure: No mitigation measures, mitigation measures and suppression measures. These features are suggestions for experienced operators to test the different level of measures and their impact to the resources needed. The aim of mitigation measures is to use Non Pharmaceutical Interventions (and vaccines or drugs, if available) not to interrupt transmission completely, but to reduce the health impact of an epidemic[2], The aim of suppression measures is to reduce the reproduction number (the average number of secondary cases each case generates), R, to below 1 and hence to reduce case numbers to low levels or (as for SARS or Ebola) eliminate human-to-human transmission.

  - No mitigation measures

    - Contacts per person - An experienced operator can define the value.

    - Probability of infection - An experienced operator can define the value of the daily probability of infection (ß).

  - Mitigation measures (can be turned on/off), Suppression measures (can be turned on/off)

    - Contacts per person - only visible if you turned on "Mitigation measures" or "Suppression measures". Different mitigation measures will influence contacts per person.

    - Probability of infection - only visible if you turned on "Mitigation measures" or "Suppression measures". Different mitigation measures will influence the probability of infection.

    - Start date of the measure (after first case reported) - only visible if you turned on "Mitigation measures" or "Suppression measures". Please introduce the day where the measures were introduced after t0 (first case).

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[2] strategy adopted generally in the 1957, 1968 and 2009 influenza pandemics. In the 2009 pandemic, for instance.

b. COVID 19 daily update

- Currently confirmed patients - It updates with data introduced on the *COVID19_DailyReportedData* tab.

- Ratio of confirmed/ suspected - It updates the data introduced on the *COVID19_DailyReportedData* tab.

c. Hospital activity and practices (in/out)

In

- % of reported cases requiring hospitalization - percentage cases that are hospitalized within the overall cases. By default, is set to 8%, but it can vary by region or country according to different factors (e.g. testing policies, age distribution, hospitalization criteria). Please use your data. During the containment phase, it is recommended that all cases are hospitalized to avoid the spread of the infection. Please, disregard this practice and consider the practice during the mitigation phase to assure a more credible and useful estimation.

  We use the following criteria to group the patients according the level of resources needed:

    - Mild - patients that can recover at home without inpatient care. They are not considered in the estimation.

    - Moderate – patients that require inpatient care but not oxygen therapy and mechanical ventilation.

    - Severe - patients that require inpatient care and oxygen therapy.

    - Critical - patients that require inpatient care and mechanical ventilation. Usually, these come from a previous stage (e.g. moderate, severe) and will pass to a lower resources level before discharge.

- % moderate cases (requiring ward) – percentage of cases within the hospitalized that do not need oxygen therapy or mechanical ventilation. By default, we consider 53%.

- % severe cases (requiring oxygen therapy) - percentage of cases within the hospitalized that require oxygen therapy. By default, we consider 41%[3].

- % critical cases (requiring mechanical ventilation) - percentage of critical cases within the hospitalized that require mechanical ventilation. This parameter is automatically calculated based on the values of the two previous parameters in order to ensure the sum up 100%. By default, we consider 6%[3].

    - % of total critical cases that require ECMO - percentage of overall critical cases that require Extracorporeal Membrane Oxygenation (ECMO). By default, we consider 0,5%[3].

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[3] Guan, W.J., Z.Y. Ni, Y. Hu, W.H. Liang, C.Q. Ou, J.X. He, L. Liu, H. Shan, C.L. Lei, D.S.C. Hui, B. Du, L.J. Li, G. Zeng, K.Y. Yuen, R.C. Chen, C.L. Tang, T. Wang, P.Y. Chen, J. Xiang, S.Y. Li, J.L. Wang, Z.J. Liang, Y.X. Peng, L. Wei, Y. Liu, Y.H. Hu, P. Peng, J.M. Wang, J.Y. Liu, Z. Chen, G. Li, Z.J. Zheng, S.Q. Qiu, J. Luo, C.J. Ye, S.Y. Zhu, N.S. Zhong, and C. China Medical Treatment Expert Group for. 2020. Clinical Characteristics of Coronavirus Disease 2019 in China. *N Engl J Med*.

- % of total critical cases that require RRT - percentage of overall critical cases that require Renal replacement therapy (RRT). By default, we consider 0,8%[3].

Out

- Moderate cases hospitalization ALoS (days) - Average length of stay for moderate Covid inpatients. By default, we consider 7 days.

- Severe cases hospitalization ALoS (days) - Average length of stay for severe Covid inpatients. By default, we consider 10 days.

- Hospitalization ALoS previous to mechanical ventilation (days) - Average length of stay previous to patients need of mechanical ventilation. We assume that all patients are previously on oxygen therapy – severe cases. By default, we consider 12 days[4].

- Critical cases mechanical ventilation stepdown ALoS (days) - Average length of stay after mechanical ventilation. We assume that the stepdown will happen with oxygen therapy – severe cases. By default, we consider 7 days.

- Critical cases hospitalization ALoS (days) - Average length of stay for critical Covid inpatients mechanically ventilated. By default, we consider 8 days[4].

- Critical cases ECMO ALoS (days) - Average length of stay for critical Covid inpatients in ECMO. By default, we consider 10 days.

- Critical cases in need of RRT (Equipment/Patient/ Day) - Number of RRT equipment used per patient and per day. By default, we consider 1.

- Average Fatality rate - It is used to calculate the need to consider stepdown resources after mechanical ventilation. By default, we consider 1,5%[3].

d. Installed capacity (to COVID patients)

Self-explanatory. The aim is to enter the capacity that the system has for COVID-19. The data can be adjusted according to the surge of resources.

e. Human resources

The tool only considers inpatient care. Please use WHO published recommendations on competencies and workload for Covid-19 care. The codes used follow the ILO International Standard Classification of Occupations.

Medical practitioners

- Moderate inpatients/ Medical practitioner 2211, 2240, 2212 FTE - Number of moderate ward beds per full-time equivalent (FTE) dedicated medical practitioners 2211, 2240, 2212. Please consider a full-week rotation to calculate the number of FTE.

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[4] Zhou, F., T. Yu, R. Du, G. Fan, Y. Liu, Z. Liu, J. Xiang, Y. Wang, B. Song, X. Gu, L. Guan, Y. Wei, H. Li, X. Wu, J. Xu, S. Tu, Y. Zhang, H. Chen, and B. Cao. 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *The Lancet* 395: 1054-62.

- Severe inpatients/ Medical practitioner 2211, 2240, 2212 FTE - Number of severe ward beds (oxygen therapy) per full-time equivalent (FTE) dedicated medical practitioners 2211, 2240, 2212. Please consider a full-week rotation to calculate the number of FTE.

- Critical inpatients mechanically ventilated / Specialist medical practitioner (ICU) 2212 FTE- Number of mechanical ventilation beds per full-time equivalent (FTE) dedicated / Specialist medical practitioner (ICU) 2212. In some constraint resources settings, ventilators can be used outside ICUs. Please consider this factor. Please also consider a full-week rotation to calculate the number of FTE.

- Critical ECMO inpatients/ Specialist medical practitioner (ICU-ECMO) 2212 FTE- Number of mechanical ventilation beds prepared for ECMO per full-time equivalent (FTE) dedicated Specialist medical practitioner (ICU-ECMO) 2212. Please also consider a full-week rotation to calculate the number of FTE.

- Critical RRT inpatients/ Specialist medical practitioner (ICU-RRT) 2212 FTE - Number of mechanical ventilation beds prepared for per full-time equivalent (FTE) dedicated Specialist medical practitioner (ICU-RRT) 2212. Please also consider a full-week rotation to calculate the number of FTE.

  e.g.

  A 20 acute beds ward has a fully dedicated physicians' staff of 7 (FTE). The ratio beds per physician is 2,85. It doesn't mean that the 7 physicians are all at the same time at ward. It means that they rotate between them self, assuring 7 FTE at the ward.

Nursing professionals

We assume that Covid-19 inpatients require nursing shifts with an equal nursing effort. In this sense, we consider the shift configuration and the number of nurses per shift. We assume the shifts duration and shifts per week are the same in all inpatient areas. The default data presented is only illustrative and operators should present their one allocation models.

- Shift configuration

  - Shift duration per Day per Nurse (h) - Number of hours per nursing shift.

  - Maximum shifts per Week per Nurse - Maximum number of hours per nursing shift, respecting maximum workload and an FTE.

- Ratios

  - Moderate inpatient/ Nursing professional 2221, 3221 (Ward) - Number of moderate beds per Nursing professional 2221, 3221 (Ward).

  - Severe inpatient (oxygen therapy) / Nursing professional 2221, 3221 (ward) - Number of severe beds (oxygen therapy) per Nursing professional 2221, 3221 (ward).

  - Critical inpatients mechanically ventilated/ Nursing professional (ICU) 2221- Number of mechanically ventilated beds per trained Nursing professional (ICU) 2221.

- Critical ECMO inpatients/ Nursing professional (ICU-ECMO) 2221 - Number of mechanically ventilated beds prepared for ECMO per trained Nursing professional (ICU-ECMO) 2221.

- Critical RRT inpatients/ Nursing professional (ICU-RRT) 2221- Number of mechanically ventilated beds prepared for RRT per trained Nursing professional (ICU-RRT) 2221.

Healthcare assistant, includes nursing and medical assistants

Please use the same logic behind the parameters described for nursing professionals.

f. HR capacity (to COVID inpatients)

Self-explanatory. The aim is to enter the HR capacity that the system has for COVID-19. The data can be adjusted according to the surge of resources.

g. HR occupational risk

- Daily Probability of Infection by Health Professionals – The probability of healthcare professionals to acquire infection per day. Please consider your own reality or other countries experience.

- Number of days in quarantine or Sick Leave –Please consider your own reality or other countries experience. By default, we assume 14 days.

- The data that appears on "Average HR ratio in quarantine/ sick leave" is automatically calculated according to both previous parameters and the HR capacity (to COVID inpatients).

SimulationResults

This tab allows the user to visualize the data that feed the graphics presented on the **Surge_Predicted_Impact** tab.

CountryPopulation

This tab allows the user to visualize population data (2020). Any data can be updated by the operator.

Annnex 1

The demonstrative SIR epidemiological model:

$$S(t) + I(t) + R(t) = N$$

$$S(t + 1) = -\beta(t) \times I(t) \times S(t) + S(t)$$

$$I(t + 1) = \beta(t) \times I(t) \times S(t) - \alpha \times I(t) + I(t)$$

$$R(t + 1) = \alpha \times I(t) + R(t)$$

$$\beta(t) = \frac{\sum_{\theta=max\,(1,t-10)}^{t} \frac{p(\theta) \times c(\theta)}{N}}{min\,(t, 10)}$$

$$p(\theta) = \begin{cases} p1, \theta < T1 \\ p2, T1 \leq \theta < T2 \\ p3, \theta \geq T2 \end{cases}$$

$$c(\theta) = \begin{cases} c1, \theta < T1 \\ c2, T1 \leq \theta < T2 \\ c3, \theta \geq T2 \end{cases}$$

$$R_0 = \frac{\frac{\sum \beta(t) * N * \left(S(t) - S(t - 1)\right) \times d}{d}}{\sum S(t) - S(t - 1)}$$

$$Reported(t) = e * (I(t) + R(t))$$

N -> Target Population

$S(t)$ -> Susceptible or healthy on day t

$I(t)$ -> Infected on day t

$R(t)$ -> Recovered on day t

α -> Recovery rate, we set it as 1/14

d -> Number of days in which an individual can infect other, we have considered 14 days

$\beta(t)$ -> probability of infection at day t

$p(\theta)$ -> probability of contagion in each interaction (per day)

$c(\theta)$ -> contacts per person

T1 -> start day of mitigation measures

T2 -> start day of suppression measures

$p1$ -> likelihood of contagion in each interaction with no mitigation measures

$p2$ -> likelihood of contagion after mitigation measures

$p3$ -> likelihood of contagion after suppression measures

$c1$ -> Contacts per person with no mitigation measures

$c2$ -> Contacts per person after mitigation measures

$c3$ -> Contacts per person after suppression measures

$Reported(t)$ -> Cumulative reported cases on day t

e-> Ratio of reported over overall infected