

## Online Appendix for “Transition Model for Coronavirus Management”

A. Djogbenou<sup>†</sup>, C. Gourieroux<sup>\*</sup>, J. Jasiak<sup>‡</sup>, P. Rilstone<sup>§</sup>, M. Bandehali<sup>¶</sup>

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### Abstract

This is the online appendix for Djogbenou, Gourieroux, Jasiak, Rilstone, and Bandehali (2021). Three sections are included. The first one provides details on the necessary data adjustments. The second section presents summary statistics on the duration of patients in each medical state. The third section shows tables with the estimated parameters for the model with durations considering only individuals diagnosed in Toronto or Great Toronto Areas, and figures on the model-based fitted counts of patients at various medical treatment stages in Ontario.

### Résumé

Ceci est l’annexe en ligne pour Djogbenou, Gourieroux, Jasiak, Rilstone et Bandehali (2021). Trois sections sont incluses. Le premier fournit des détails sur les ajustements de données nécessaires. La deuxième section présente des statistiques sommaires sur la durée des patients dans chaque état médical. La troisième section montre des tableaux des paramètres estimés pour le modèle avec les durées en tenant compte uniquement des personnes diagnostiquées dans les régions de Toronto ou du Grand Toronto, et des figures montrant les estimations basées sur le modèle du nombre de patients à diverses étapes de traitement médical en Ontario.

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<sup>†</sup>York University, Canada, *e-mail*: daa@yorku.ca

<sup>\*</sup>University of Toronto, Toulouse School of Economics and CREST, *e-mail*: gouriero@ensae.fr

<sup>‡</sup>York University, Canada, *e-mail*: jasiakj@yorku.ca

<sup>§</sup>York University, Canada, *e-mail*: pril@yorku.ca

<sup>¶</sup>York University, Canada, *e-mail*: may1979@yorku.ca

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## Appendix B.1

### Data Adjustments

This paper is based on daily records of 18722 individuals, who were diagnosed with COVID-19 over the period of 104 days between January 23 and May 05, 2020. The dataset was built by the Public Health Ontario (PHO) from combined records provided by the iPHIS (integrated Public Health Information System) and CORES (Toronto Public Health Coronavirus Rapid Entry System). These data include variables that describe the phase of detection and the types of medical care of each patient (referred to as client in the database). To construct the joint individual histories as presented in Section 2.5, we use the information on each of the 18722 individuals provided by the following variables:

- case reported date
- hospitalized - yes, no, unknown
- hospitalization admit date
- hospital discharge date
- ICU (Intensive Care Unit) - yes or no
- ICU start date
- ICU end date
- ER (Emergency Room) visit - yes or no
- ER visit start date
- ER visit end date
- intubation - yes or no
- intubation start date
- intubation end date
- isolation - yes, no, unknown
- isolation start date - before hospitalization or ER

- isolation end date
- ventilator - yes, no, unknown
- ventilation start date
- ventilation end date
- outcome - recovered, pending, fatal
- resolved - yes, no, fatal
- client death date

Given that some of the entries are missing or misreported, we have implemented the following data adjustments:

1. States are determined by the availability of the beginning date or the final date in the states.
2. The Case Reported Dates are used as the date of detection. The first date of the reported detected case in our data is January 23rd, 2020. The last date is May 5th, 2020.
3. The individual histories were constructed from the detection date until May 5th, 2020.
4. Some cases were hospitalized for other reasons many weeks before the outbreak and the detection dates. The relevant hospitalization period is considered as the one after the COVID-19 detection date.
5. The individual in row 4506 has a missing value for the death date. We set it equal to the final date.
6. If the first or the last date in a state is missing, we assume the individual spent one day in that state. For instance, most people who went to the ER have only one date reported. This is consistent with the fact that most people often leave the ER in one day.
7. For the individual in row 13306, dates were reported with an error. We treat these dates as missing information.
8. The beginning and end dates in states were often inverted. We fixed that.

9. For individuals in rows 6425, 6596, and 14582, the start and end dates in the emergency room were 18 MARCH 2020 to 18 APRIL 2020, 20 MARCH 2020 to 20 APRIL 2020, and 14 MARCH 2020 to 14 APRIL 2020, respectively. This corresponds to one month spent in the emergency room and cannot be accurate. We assumed that the terminal period month should be MARCH and corrected the end date.

The dataset also contains variables of individual characteristics, such as the age, gender and also detailed information on complications from disease, symptoms, pre-existing health conditions, source of contamination and occupation. The variables of age and gender contain relatively few missing values, which can often be recovered from the DOB and individual identifiers, although, due to differences in identifiers used by the iPHIS and CORES this can entail additional errors. In the remaining variables a considerable number of entries are missing, making most of those variables not usable for empirical analysis. For example, 17181 out of 18722 records on pre-existing conditions are missing. The variable of diagnosing health unit area is also available in the data set. The records on that variable are complete and are used in our analysis.

## Appendix B.2

### Sojourn Times - Descriptive Statistics

#### 1. State D

*Duration in D before ER.*

There are N =123 patients with only 2 durations over the first 30 days.

	N	min	25%	median	75%	max	mean	var
total	123	1	2	3	8	40	5.813	37.940

*Duration in D before Hospitalized*

	N	min	25%	median	75%	max	mean	var
total	463	1	2	4	8	36	5.460	20.309

*Duration in D before ICU*

There are only 5 cases over the first 30 days. One individual spends one day to ICU and returns to state D.

	N	min	25%	median	75%	max	mean	var
total	77	1	2	3.5	6	32	4.644	19.432

*Duration in D before Ventilation*

There are 18 individuals who move from D to Ventilation. These transitions took place after April 02.

	N	min	25%	median	75%	max	mean	var
total	18	1.0	2.0	4.0	6.5	26.0	5.611	40.722

*Duration in D before Intubation*

	N	min	25%	median	75%	max	mean	var
total	82	1	2	4	6	14	4.365	8.185

*Duration in D before Recovered.*

These individuals may have undergone medical treatments, returned to D and were reported as Recovered.

	N	min	25%	median	75%	max	mean	var
total	13207	1	17	24	33	103	25.147	109.524

### *Duration in D before Deceased*

There are no transitions from D to Deceased over the first 62 days. One individual dies after 49 days in isolation without any medical treatment.

	N	min	25%	median	75%	max	mean	var
total	851	1	4	7	11	49	7.994	35.323

The durations prior to transitions from state 3 of De are given in Figure 5.

## **2. State ER**

### *Duration in ER before return to D*

	N	min	25%	median	75%	max	mean	var
total	137	1	1	1	1	25	1.781	12.157

### *Duration in ER before Hospitalization*

The results are based on N=6 patients.

	N	min	25%	median	75%	max	mean	var
total	6	1	1	3	5	7	3.333	7.066

One individual has recovered on the last day of sampling period on day 104 after staying in ER. Another individual died after 2 days in ER.

## **3. State Hospitalization**

### *Duration in Hospitalization before return to D*

	N	min	25%	median	75%	max	mean	var
total	1084	1	1	3	7	34	4.959	27.008

### *Duration in Hospitalization before ER*

One individual made that transition after 1 day in hospital.

### *Duration in Hospitalization before ICU*

These durations are recorded after March 20.

	N	min	25%	median	75%	max	mean	var
total	35	1.0	1.0	2.0	3.5	15.0	3.085	10.668

### *Duration in Hospitalization before Ventilation.*

These transitions start on day 59 of the sampling period, about March 22.

	N	min	25%	median	75%	max	mean	var
total	6	1.00	1.25	2.50	3.00	3.00	2.166	0.966

#### *Duration in Hospitalization before Intubation*

These transitions start on day 53 , i.e. about March 16

	N	min	25%	median	75%	max	mean	var
total	31	1	1	2	3	12	2.774	6.780

#### *Duration in Hospitalization before Recovered*

There are only 3 transitions after hospitalization of 28, 9 and 39 days.

#### *Durations of Hospitalization before Death*

The are no transitions to state 9 from Hospital over the first 30 days.

	N	min	25%	median	75%	max	mean	var
total	215	1	3	5	10	92	7.525	71.568

### **4. State ICU**

#### *Duration in ICU before D*

There are only 2 transitions before day 60 of March 23.

	N	min	25%	median	75%	max	mean	var
total	122	1.00	1.00	1.00	6.75	33.00	5.327	47.627

#### *Duration in ICU before Hospitalization*

There is only one transition before day 60.

	N	min	25%	median	75%	max	mean	var
total	66	1	2	3	6	19	4.863	18.673

#### *Duration in ICU before Ventilation*

There are only 4 durations between days 71 (April 3) and 99 (April 30) of 1,3 ,6 and 7 days.

#### *Duration in ICU before Intubation*

There are no transitions before March 23 and only 4 durations between April 22 and the end of sample

	N	min	25%	median	75%	max	mean	var
total	21	1	1	1	2	9	2.285	4.914

#### *Duration in ICU before Recovered*

One individual makes a transition into R on day 104 (May 04) after 20 days in the ICU.

#### *Duration in ICU before Death*

There are no transitions before day 60 (March 23).

	N	min	25%	median	75%	max	mean	var
total	34	1	2	5	14	35	4.863	18.673

## 5. State Ventilation

### *Duration in Ventilation before return to D*

There are no durations before day March 23 (day 60).

	N	min	25%	median	75%	max	mean	var
total	31	1	1	1	2	26	4.774	57.580

### *Duration in Ventilation before return to Hospitalized*

There are only 4 durations between days 76 and 84 of length 2,8,1, and 25 days, respectively.

### *Duration in Ventilation before return to ICU*

There are 3 durations between days 76 and 88 of length 1, 8 and 9.

### *Duration in Ventilation before Intubation*

There is only one 1-day duration on day 61 (March 24).

### *Duration in Ventilation before Death*

	N	min	25%	median	75%	max	mean	var
total	7	5.0	7.5	9.0	11.0	16.0	9.571	12.952

## 6. State Intubation

### *Duration in Intubation before return to D*

There is only one transition before day 60 (March 23).

	N	min	25%	median	75%	max	mean	var
total	104	1.0	1.0	1.0	8.5	32.0	6.586	96.380

### *Duration in Intubation before return to Hospitalized*

There are no transitions before day 60 (March 23).

	N	min	25%	median	75%	max	mean	var
total	10	1.00	7.50	10.50	11.75	17.00	9.9	22.988

### *Duration in Intubation before return to ICU*

There are no transitions before day 60 (March 23).

	N	min	25%	median	75%	max	mean	var
total	47	1.0	5.5	12.0	16.5	29.0	11.80851	59.679



*Duration in Intubation before Ventilation*

All durations occurred between days 67 and 83.

	N	min	25%	median	75%	max	mean	var
total	8	1.0	1.0	10.0	18.5	29.0	11.25	.

*Duration in Intubation before Recovered*

There are 2 durations with transition on day 104 of 35 and 7 days.

*Duration in Intubation before Death*

	N	min	25%	median	75%	max	mean	var
total	67	1.0	3.0	7.0	14.5	30.0	9.149	53.886

## Appendix B.3

### Additional Tables and Figures

Table 7: Estimated Coefficients for Individuals Diagnosed in Toronto

TRANSITION FROM D													
States	ER		H		ICU		V		T		R		DE
Parameters	$\beta_{1,1}$	$\beta_{1,2}$	$\beta_{1,3}$	$\beta_{1,4}$	$\beta_{1,5}$	$\beta_{1,6}$	$\beta_{1,7}$	$\beta_{1,8}$	$\beta_{1,9}$	$\beta_{1,10}$	$\beta_{1,11}$	$\beta_{1,12}$	$\beta_{1,13}$
Estimates	-7.962	0.005	-4.519	-0.081	-5.825	-0.122	-10.820	0.021	-6.067	-0.082	-2.667	-0.023	-6.283
Standard Errors	0.321	0.013	0.605	0.025	0.435	0.023	0.912	0.026	0.617	0.032	1.171	0.014	0.260
TRANSITION FROM ER													
States	D	H	R	DE									
Parameters	$\beta_{2,1}$	$\beta_{2,2}$	$\beta_{2,3}$	$\beta_{2,4}$									
Estimates	0.504	-2.269	-20.390	-20.390									
Standard Errors	0.374	0.494	0.433	0.433									
TRANSITION FROM H													
States	D		ER		ICU		V		T		R		DE
Parameters	$\beta_{3,1}$	$\beta_{3,2}$	$\beta_{3,3}$	$\beta_{3,4}$	$\beta_{3,5}$	$\beta_{3,6}$	$\beta_{3,7}$	$\beta_{3,8}$	$\beta_{3,9}$	$\beta_{3,10}$	$\beta_{3,11}$	$\beta_{3,12}$	$\beta_{3,13}$
Estimates	-0.079	-0.224	-7.064	-9.267	-3.044	-0.290	-14.720	-22.130	-3.307	-0.249	-7.290	-0.059	-3.149
Standard Errors	0.183	0.039	0.640	0.285	0.514	0.096	N/A	N/A	0.564	0.082	1.078	0.007	0.289
TRANSITION FROM ICU													
States	D		H		V		T		R		DE		
Parameters	$\beta_{4,1}$	$\beta_{4,2}$	$\beta_{4,3}$	$\beta_{4,4}$	$\beta_{4,5}$	$\beta_{4,6}$	$\beta_{4,7}$	$\beta_{4,8}$	$\beta_{4,9}$	$\beta_{4,10}$	$\beta_{4,11}$		
Estimates	0.042	-0.301	-0.349	-0.311	-21.597	-37.998	-0.183	-0.539	-113.040	5.507	-3.357		
Standard Errors	0.490	0.084	0.260	0.054	N/A	N/A	0.418	0.134	9.866	0.542	0.411		
TRANSITION FROM V													
States	D		H		ICU		T		R		DE		
Parameters	$\beta_{5,1}$	$\beta_{5,2}$	$\beta_{5,3}$	$\beta_{5,4}$	$\beta_{5,5}$	$\beta_{5,6}$	$\beta_{5,7}$	$\beta_{5,8}$	$\beta_{5,9}$	$\beta_{5,10}$	$\beta_{5,11}$		
Estimates	0.894	-0.325	16.283	-16.634	-10.040	-29.354	1.5113	-15.833	-53.934	-66.329	-3.045		
Standard Errors	0.857	0.194	0.462	0.462	N/A	N/A	0.266	0.266	N/A	N/A	0.715		
TRANSITION FROM T													
States	D		H		ICU		V		R		DE		
Parameters	$\beta_{6,1}$	$\beta_{6,2}$	$\beta_{6,3}$	$\beta_{6,4}$	$\beta_{6,5}$	$\beta_{6,6}$	$\beta_{6,7}$	$\beta_{6,8}$	$\beta_{6,9}$	$\beta_{6,10}$	$\beta_{6,11}$		
Estimates	-0.693	-0.168	-4.220	-0.113	-2.698	-0.0941	-6.734	0.043	-4.576	-0.196	-3.184		
Standard Errors	0.272	0.045	0.743	0.049	0.527	0.029	0.991	0.026	1.051	0.009	0.163		

Table 8: Estimated Coefficients for Individuals Diagnosed in other Great Toronto Areas

TRANSITION FROM D													
States	ER		H		ICU		V		T		R		DE
Parameters	$\beta_{1,1}$	$\beta_{1,2}$	$\beta_{1,3}$	$\beta_{1,4}$	$\beta_{1,5}$	$\beta_{1,6}$	$\beta_{1,7}$	$\beta_{1,8}$	$\beta_{1,9}$	$\beta_{1,10}$	$\beta_{1,11}$	$\beta_{1,12}$	$\beta_{1,13}$
Estimates	-9.964	0.052	-5.766	-0.045	-9.536	0.007	-9.024	-0.040	-7.144	-0.074	-2.752	-0.021	-5.988
Standard Errors	0.708	0.022	0.581	0.024	1.329	0.045	1.040	0.043	0.613	0.025	1.168	0.015	0.103
TRANSITION FROM ER													
States	D	H	R	DE									
Parameters	$\beta_{2,1}$	$\beta_{2,2}$	$\beta_{2,3}$	$\beta_{2,4}$									
Estimates	1.135	-1.504	-17.557	-17.557									
Standard Errors	0.566	0.619	0.572	0.572									
TRANSITION FROM H													
States	D		ER		ICU		V		T		R		DE
Parameters	$\beta_{3,1}$	$\beta_{3,2}$	$\beta_{3,3}$	$\beta_{3,4}$	$\beta_{3,5}$	$\beta_{3,6}$	$\beta_{3,7}$	$\beta_{3,8}$	$\beta_{3,9}$	$\beta_{3,10}$	$\beta_{3,11}$	$\beta_{3,12}$	$\beta_{3,13}$
Estimates	0.826	-0.361	-11.631	-13.826	-5.499	0.003	-1.998	-0.998	-3.372	-0.296	-45.790	1.082	-3.413
Standard Errors	0.156	0.037	0.191	0.191	0.573	0.027	0.847	0.385	0.713	0.027	2.459	0.088	0.212
TRANSITION FROM ICU													
States	D		H		V		T		R		DE		
Parameters	$\beta_{4,1}$	$\beta_{4,2}$	$\beta_{4,3}$	$\beta_{4,4}$	$\beta_{4,5}$	$\beta_{4,6}$	$\beta_{4,7}$	$\beta_{4,8}$	$\beta_{4,9}$	$\beta_{4,10}$	$\beta_{4,11}$		
Estimates	0.670	-0.213	-4.076	-0.046	-17.976	-21.107	33.569	-35.248	-8.893	-6.774	-4.151		
Standard Errors	0.271	0.052	0.321	0.077	0.990	0.056	0.984	0.232	0.207	0.207	0.255		
TRANSITION FROM V													
States	D		H		ICU		T		R		DE		
Parameters	$\beta_{5,1}$	$\beta_{5,2}$	$\beta_{5,3}$	$\beta_{5,4}$	$\beta_{5,5}$	$\beta_{5,6}$	$\beta_{5,7}$	$\beta_{5,8}$	$\beta_{5,9}$	$\beta_{5,10}$	$\beta_{5,11}$		
Estimates	-0.581	-0.193	-0.878	-0.203	-3.753	-0.084	-1.891	-0.427	-10.611	-10.160	-3.241		
Standard Errors	0.863	0.171	1.023	0.100	0.947	0.151	0.290	0.290	N/A	N/A	0.666		
TRANSITION FROM T													
States	D		H		ICU		V		R		DE		
Parameters	$\beta_{6,1}$	$\beta_{6,2}$	$\beta_{6,3}$	$\beta_{6,4}$	$\beta_{6,5}$	$\beta_{6,6}$	$\beta_{6,7}$	$\beta_{6,8}$	$\beta_{6,9}$	$\beta_{6,10}$	$\beta_{6,11}$		
Estimates	0.441	-0.270	-0.639	-0.563	-0.785	-0.300	-0.666	-18.010	-53.934	-66.329	-3.150		
Standard Errors	0.928	0.169	1.071	0.025	0.481	0.033	1.190	0.086	0.231	0.231	0.393		

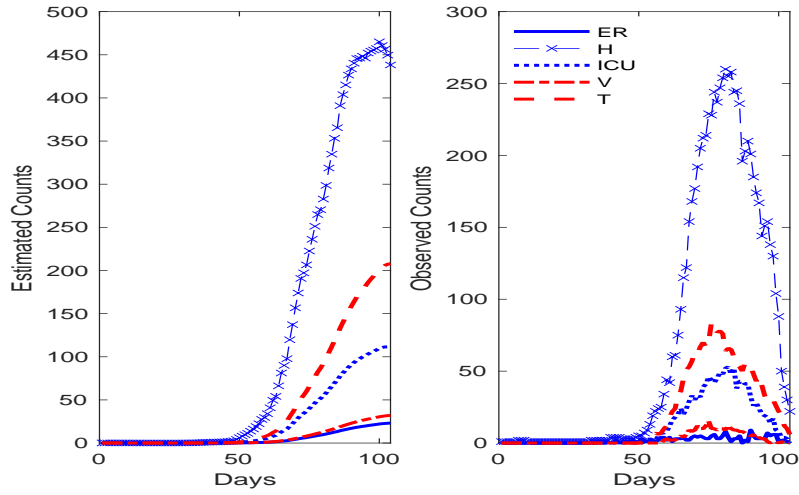


FIGURE 15: Fitted and Observed Daily Counts of Medical Care: Duration Dependent Model

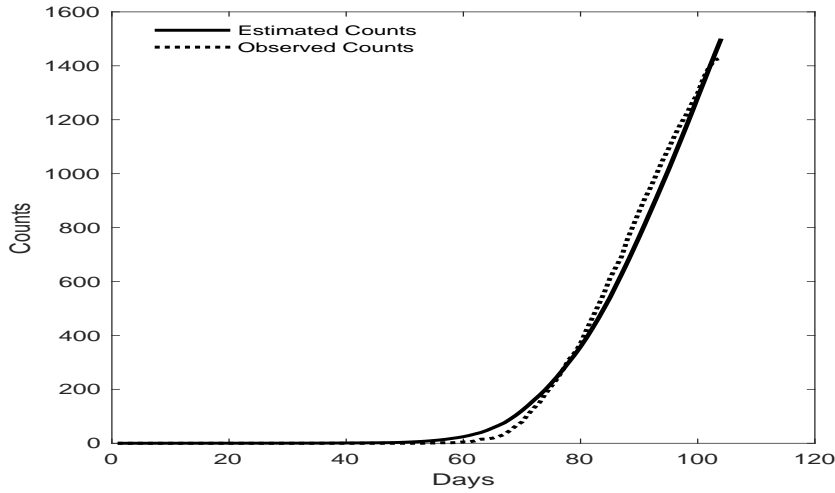


FIGURE 16: Fitted and Observed Cumulative Counts of Deaths: Duration Dependent Model

## REFERENCES

Djogbenou, A., Gourieroux, C., Jasiak, J., Rilstone, P., and M. Bandehali (2021): Transition Model for Coronavirus Management, Canadian Journal of Economics, forthcoming.