School Re-opening Simulations with COVID-19 Agent-Based Model for Philippine Regions

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Introduction

- Schools in the Philippines have been closed since **March 2020** due to the COVID-19 Pandemic
- There is a total of **3.6M COVID-19 cases** recorded in the Philippines, and currently we have **2,436 active cases***
- A total of **71M individuals*** have received a full course of vaccination. (**80%** of the target population)
- On **September 2021**, the Philippine Government approved a pilot run of limited in-person classes in low risk areas.

***as of 04 June 2022**

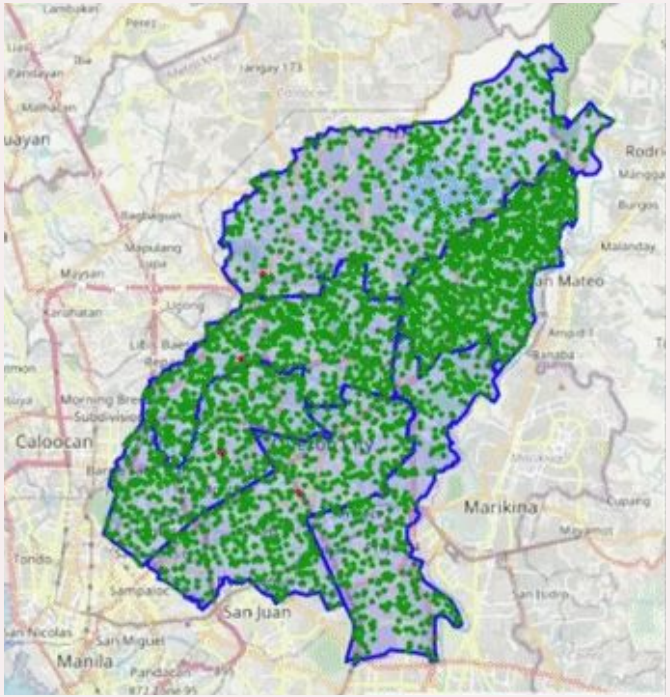
Which regions can safely reopen schools?

Is the vaccine coverage enough?

Methodology

COVID-19 Agent-Based Model

- Developed by **Ang and Celeste (2021)** [1]
- Based on the *Age-Stratified, Quarantine- Modified SEIR with Non-Linear Incidence Rates Model* **(ASQ-SEIR-NLIR Model)** [2, 3, 4]



Mathematical Basis:
ASQ-SEIR-NLIR

- **U** is the **Age-Stratified Infection expectation** (based on the Age-Stratification Theory)
- **Q(t)** account for the **effects of the quarantine** (limited interaction between infectious and susceptible).
- **Susceptible**, **Exposed**, **Infected**, **Removed** compartments
- Non Linear Incidence Rates include **behavioral** and **disease-resistance** factors.

Model Parameters

Parameter	Value
Infection Rate	Age distribution of infections in NCR
Death Rate	Age distribution of deaths in NCR
Recovery Rate	Age distribution of recoveries in NCR
Average Incubation Period	5 days [5]
Average Infectious Period	11.5 days
Wearing Masks	100% *(assumption)*
Protection from Wearing Masks	65% [6]
Physical Distancing	60% *(assumption)*
Protection from Physical Distancing	90% [6]

Model Compartments (SEIRDV)

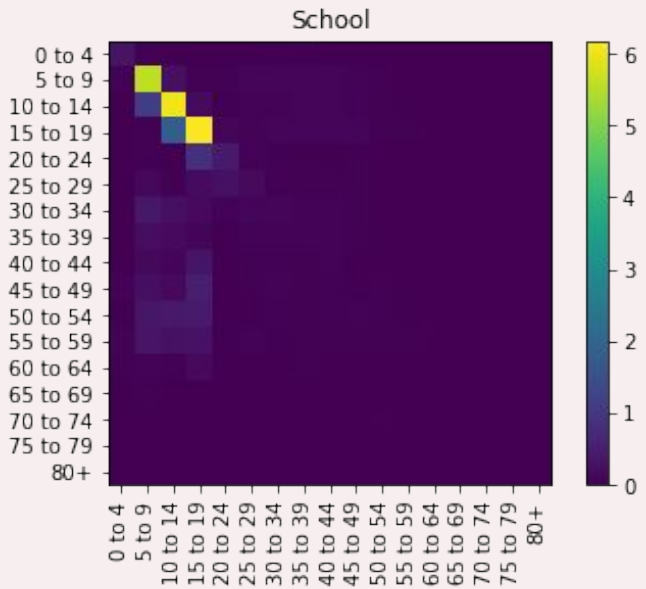
- Removed compartment disaggregated into **Recovered (R)**, **Dead (D),** and **Vaccinated (V).** These values are sourced from the DOH data drop of cases
- Total Population **N = S + E + I + R + D + V**
- **Exposed (E)** is assumed to be 0 (no available data)
- **Vaccination (V)** coverage is varied throughout each scenario: 0%, 25%, 50%, 75%, 100%

i	Vaccine	Efficacy (E)	Supply (S)
1	Sinovac	0.650	41,500,000
2	Astrazeneca	0.704	11,103,340
3	Pfizer	0.950	23,328,630
4	Sputnik v	0.916	1,290,000
5	Johnson & johnson	0.669	3,240,850
6	Moderna	0.941	9,985,800
7	Sinopharm	0.790	1,100,000

Mathematical Expectation of Vaccine Efficacy is 0.770840197

Social Contact Matrices

- Social Contact Matrices of Prem et al. [7] (2018) as Social Contact Probabilities
- Pre-pandemic average number of contacts in a day in the school for Ph



School Reopening Simulations

We performed **two sets** of simulations:

- **Omicron Simulations** (from onset to 17 January 2022)
- **Delta Simulations** (from onset to 15 September 2021)

School Reopening Simulations

- The **Agent to Region Population ratio** (1 agent : 257 people) is normalized to the national average
- Simulation is ran for the 17 regions of the Philippines
- **No Opening, No Vaccination** vs **100% School Reopening scenario** (with varying vaccine coverages)
- Model is ran for 300 steps and 20 iterations

School Reopening Viability (SRV)

- We computed for the **School Reopening Viability (SRV)** by subtracting our computed downticks from the vaccine coverage of each regions
- A **positive SRV** means that a region **can already reopen** its schools at full capacity without an increase in deaths or infections compared to the control

Vaccine Coverage

As of Feb 13

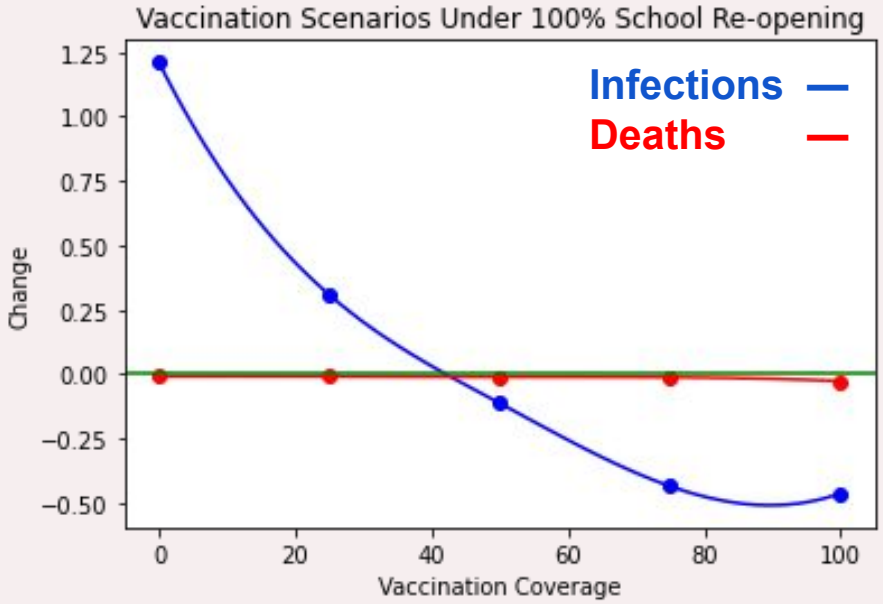
Regions	Vaccine Coverage
NCR	79.9%
CAR	57.8%
1	60.5%
2	58.5%
3	58.4%
4-A	55.8%
4-B	48.0%
5	49.0%

Regions	Vaccine Coverage
6	55.4%
7	45.2%
8	49.0%
9	49.6%
10	52.3%
11	52.3%
12	42.9%
13	48.8%
BARMM	19.6%

Delta Simulations

NCR Results

- Downtick in Infections reached at **43% vaccination**
- Downtick in Deaths reached at **0% vaccination** (trend for most regions)



Infection and Death Downticks for the Delta Simulations

Regions	Infection Downtick	Death Downtick
NCR	39.66%	0%
CAR	41%	0%*
1	55.9%	0%*
2	30%	0%*
3	12.31%	3.57%
4-A	43.31%	0%
4-B	25%	0%
5	45%	0%*

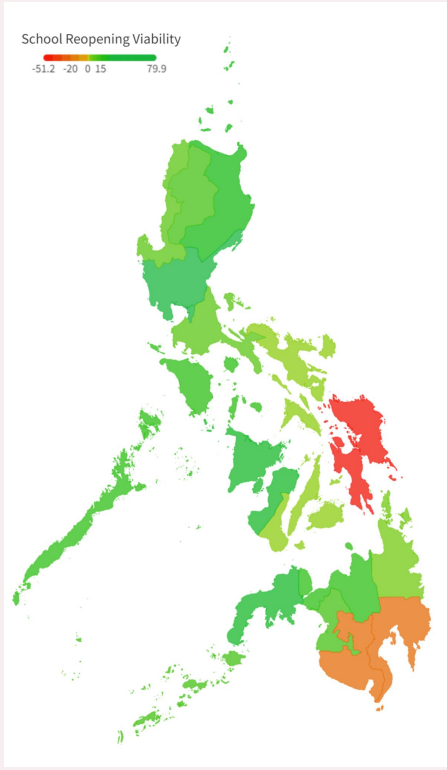
Regions	Infection Downtick	Death Downtick
6	18.62%	11.11%
7	34.2%	25%
8	76.14%	12.5%*
9	12%	0%
10	29.17%	0%
11	64.13%	50%
12	51.2%	0%
13	41.7%	100%
BARMM	3.85%	0%

*The negative change is first achieved at this vaccine coverage but a positive change appeared at a higher vaccine coverage.

SRV in terms of Infections for the Delta Simulations

Regions	SRV (Infection)	SRV (Death)
NCR	40.24	79.9
CAR	16.8	57.8
1	4.6	60.5
2	28.5	58.5
3	46.09	54.8
4-A	12.49	55.8
4-B	23	48
5	4	49

Regions	SRV (Infection)	SRV (Death)
6	36.78	44.3
7	11	20.2
8	**-27.14**	**36.5**
9	37.6	-0.4
10	23.13	52.3
11	**-11.83**	**2.3**
12	**-8.3**	**42.9**
13	7.1	-51.2
BARMM	15.75	19.6



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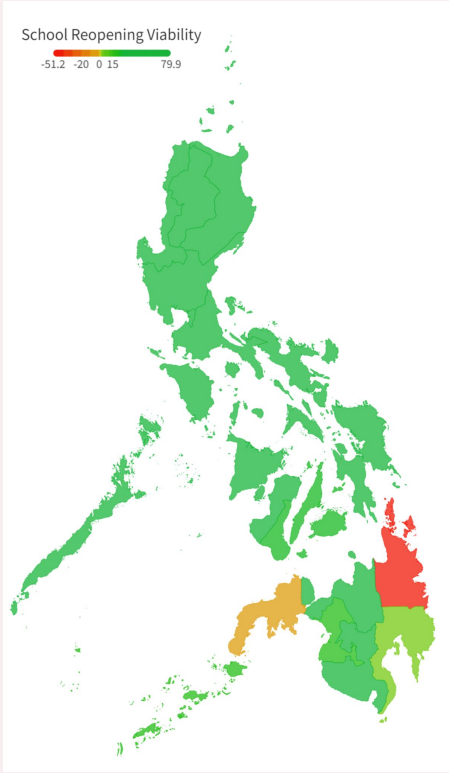
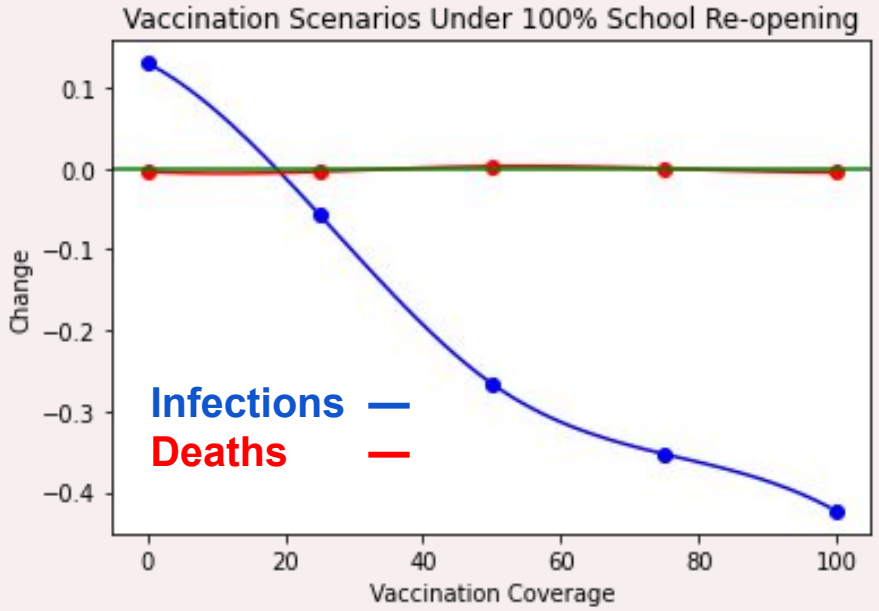
11	-11.83	2.3
12	-12.87	42.9
13	**8.3**	**-51.2**
BARMM	15.75	19.6



Omicron Simulations

NCR Results

- Downtick in Infections reached at **17% vaccination**
- Downtick in Deaths reached at **0% vaccination** (trend for most regions)



Infection and Death Downticks for the Omicron Simulations

Regions	Infection Downtick	Death Downtick
NCR	17.4%	0%
CAR	23.61%	0%*
1	8.33%	45%
2	14.58%	0%*
3	43.41%	42.86%
4-A	26.22%	0%
4-B	20.59%	0%*
5	45%	0%*

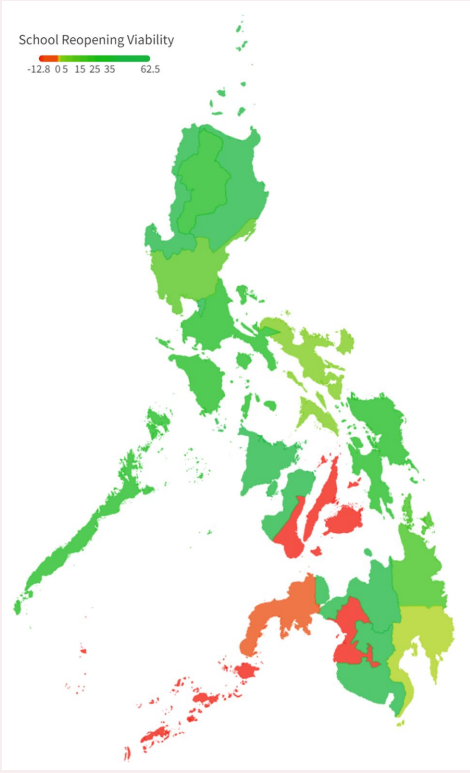
Regions	Infection Downtick	Death Downtick
6	12.14%	0%
7	58%	0%
8	16.07%	0%*
9	53.57%	0%*
10	55.83%	0%*
11	50.81%	0%
12	0%	0%*
13	29.41%	56.25%*
BARMM	31.67%	0%

*The negative change is first achieved at this vaccine coverage but a positive change appeared at a higher vaccine coverage.

SRV in terms of Infections for the Omicron Simulations

Regions	SRV (Infection)	SRV (Death)
NCR	62.5	79.9
CAR	34.19	57.8
1	52.17	15.5
2	43.92	58.5
3	14.99	15.54
4-A	29.58	55.8
4-B	27.41	48
5	4	49

Regions	SRV (Infection)	SRV (Death)
6	43.26	55.4
7	**-12.8**	**45.2**
8	32.93	49
9	**-3.97**	**49.6**
10	52.3	18.97
11	1.49	52.3
12	42.9	42.9
13	19.39	-7.45
BARMM	**-12.07**	**19.6**



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4-B	27.41	48
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7	-12.8	45.2
8	32.93	49
9	-3.97	49.6
10	52.3	18.97
11	1.49	52.3
12	42.9	42.9
13	**19.39**	**-7.45**
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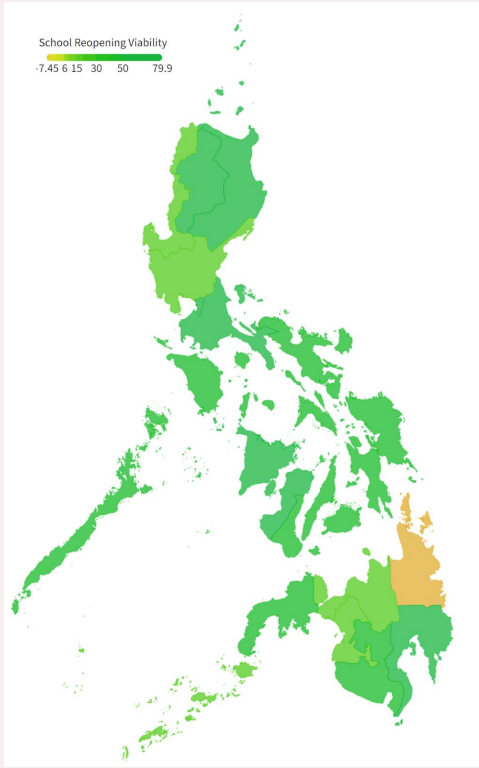


Update

- SRV values are updated with the vaccination coverage data dated Apr 19
- Updated maps are added in the COVID-19 site

Vaccine Coverage

As of Apr 19

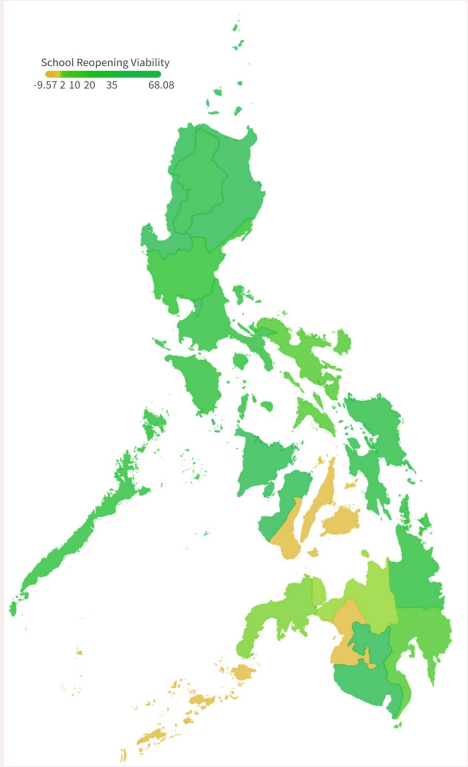
Regions	Vaccine Coverage
NCR	85.48%
CAR	62.81%
1	65.7%
2	64%
3	63.77%
4-A	60.72%
4-B	52.4%
5	52.85%

Regions	Vaccine Coverage
6	75.3%
7	60.71%
8	53.91%
9	60.71%
10	56.7%
11	56.09%
12	47.43%
13	55.32%
BARMM	22.1%

SRV in terms of Infections for the Omicron Simulations

Regions	SRV (Infection)	SRV (Death)
NCR	68.08	85.48
CAR	39.2	62.81
1	57.37	20.7
2	49.42	64
3	20.36	20.91
4-A	34.5	60.72
4-B	31.81	52.4
5	7.85	52.85

Regions	SRV (Infection)	SRV (Death)
6	48.57	60.71
7	**-5.54**	**52.46**
8	37.84	53.91
9	1.31	54.88
10	0.87	56.7
11	5.28	56.09
12	47.43	47.43
13	**25.91**	**-0.93**
BARMM	**-9.57**	**22.1**



SRV in terms of Deaths for the Omicron Simulations

Regions	SRV (Infection)	SRV (Death)
NCR	68.08	85.48
CAR	39.2	62.81
1	57.37	20.7
2	49.42	64
3	20.36	20.91
4-A	34.5	60.72
4-B	31.81	52.4
5	7.85	52.85

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6	48.57	60.71
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8	37.84	53.91
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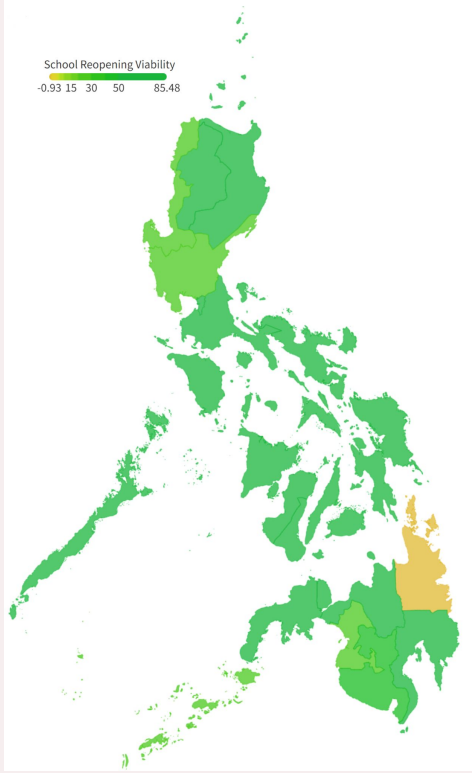
13	**25.91**	**-0.93**
BARMM	**-9.57**	**22.1**



Discussion

- Regions with lower vaccination rates have less protection from deaths and infections.
- For the region of concern, we believe their corresponding healthcare facilities could handle the influx of new cases

Conclusion

- All Regions except **Central Visayas, and BARMM** can reopen their schools fully.
- **Gradual school reopening** instead of full is recommended for the **Caraga region**. Aside from this, monitoring of the region's hospital utilization and ramping up vaccination efforts is also recommended.

Recommendations

- When schools reopen, **safety precautions** should still be observed—wearing of masks and physical distancing must still be mandatory, as in our assumption.
- **Vaccination efforts must be improved**, especially in regions in Visayas and Mindanao.
- **Gradual school reopening** instead of outright full reopening is also suggested.
- For BARMM and Central Visayas a **school reopening with limited capacity** may be considered.

THANK YOU!

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