Before we close the book on COVID

Mortality impact of the pandemic in Asia

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Agenda

1. Background
2. Pre-pandemic mortality trend
3. Mortality trend during pandemic
4. Excess mortality in pandemic
5. Stochastic mortality model
6. Long-term mortality impact
7. Implications, recommendations, limitations and conclusions

BACKGROUND

A collaboration with GAIP

Global Asia Insurance Partnership

- A tripartite partnership between the insurance industry, supervisors and regulators, and academia
- NTU is GAIP's key academic partner
- Research report: "*Mortality impact of the COVID-19 pandemic in East and Southeast Asia*"

  https://www.gaip.global/wp-content/uploads/2023/07/COVID-19-Mortality-Impact-in-Asia-.pdf

Motivation

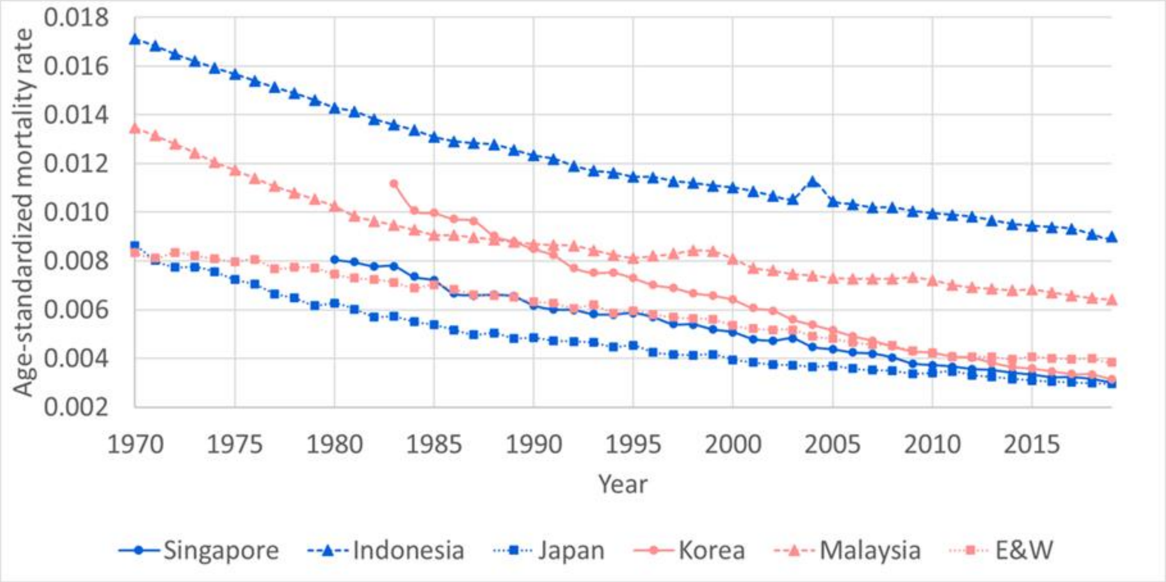
- Asia focus
- Forward-looking view
- Actuarial context
- Tool and inspiration

Country (region) considered

- General population mortality data since 1970s/1980s
- Singapore, Japan, Korea, England & Wales: 2020 – 2022 pandemic data
- Malaysia: 2020 – 2021 pandemic data
- Indonesia: 2020 pandemic data
- England & Wales included for comparison purpose

PRE-PANDEMIC MORTALITY TREND

Age-standardized mortality rate



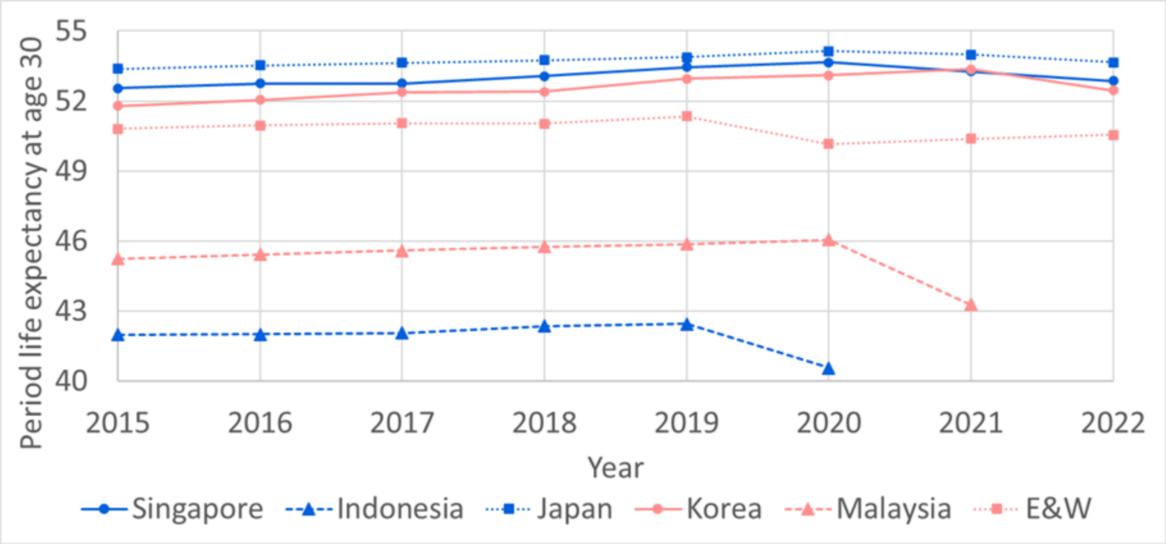
- Long-term downward trend
- Distinctive levels of mortality rate by country
- Steep decrease in Singapore and Korea
- Deceleration of mortality improvement in Japan

MORTALITY TREND DURING THE PANDEMIC

Factors impacting mortality during COVID

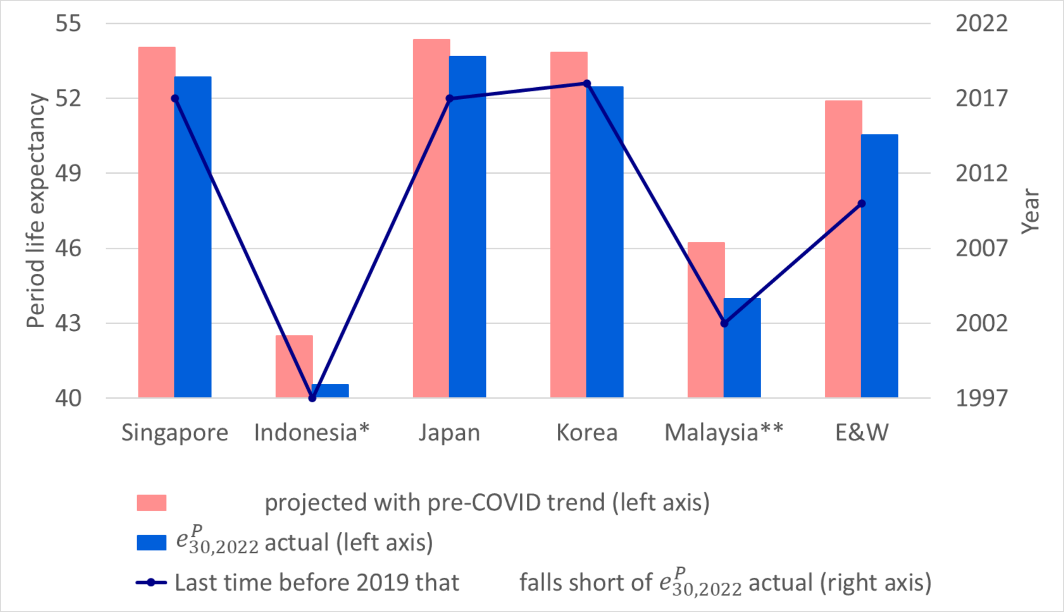
- Acute COVID-19 infection
- Delay/avoidance of medical care, strain on the health care system
- Behavioural issues during the pandemic
- Reduction in other transmissible diseases
- Fewer road traffic and occupational accidents, reduced air pollution

Period life expectancy at age 30



- **Singapore, Japan and Korea**: small gain followed by moderate deterioration in mortality
- **England & Wales**: sizable mortality deterioration followed by small recoveries, but still not back to pre-pandemic level
- **Indonesia and Malaysia**: significant mortality deterioration with small gain in Malaysia in 2020

Period life expectancy at age 30



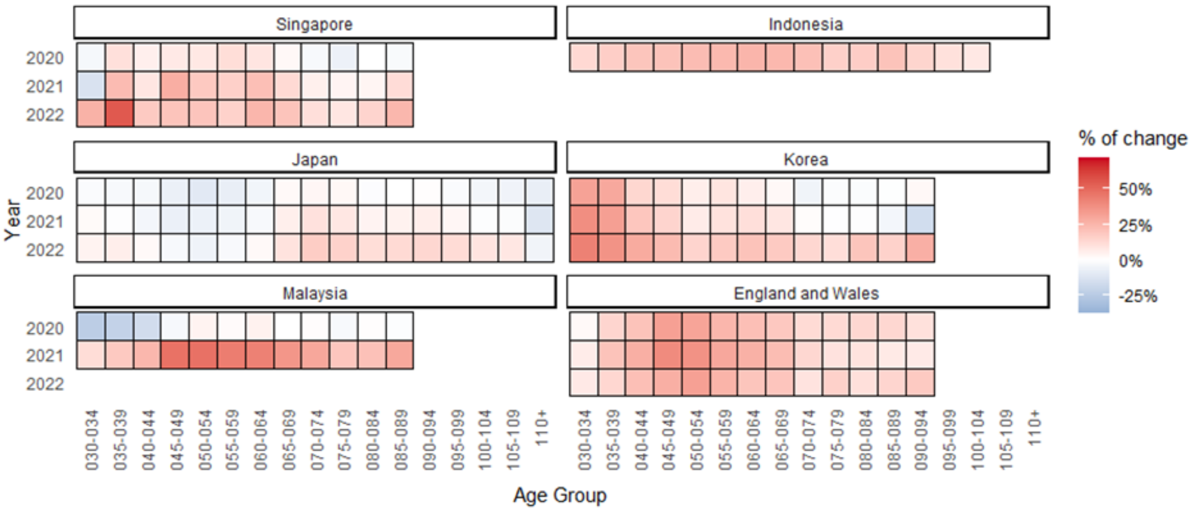
* Results as of 2020.

** 2022 actual based on simulation.

- **Singapore, Japan and Korea**: ~1 year difference actual vs. expected, worth ~5 years of mortality improvement
- **England & Wales**: ~1 year difference actual vs. expected but worth ~12 years of mortality improvement due to slow rate of improvement in recent years
- **Indonesia and Malaysia**: ~2 year difference actual vs. expected but worth about two decades of mortality improvement due to slow rate of improvement

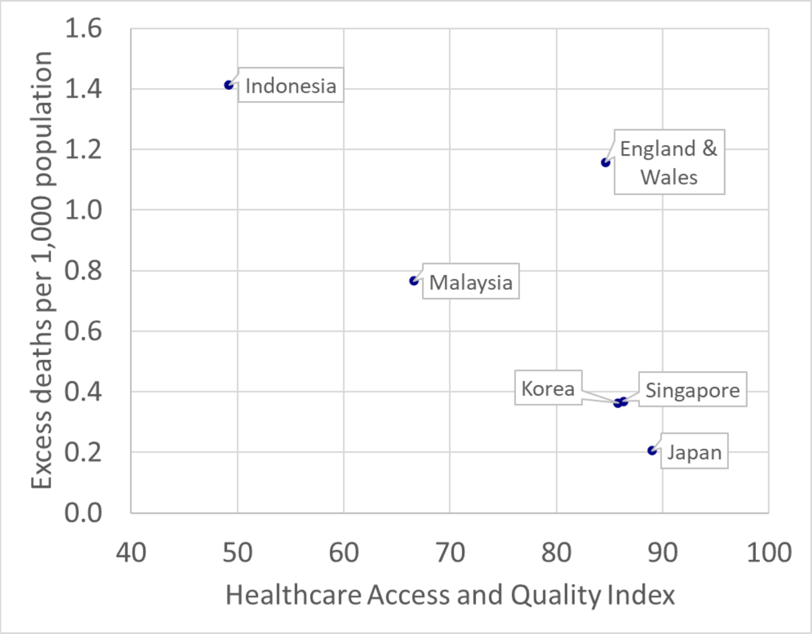
EXCESS MORTALITY IN PANDEMIC

Age-specific excess mortality in pandemic



- Different impact by country and by year
- Some mortality gain in 2020/2021 in Singapore, Japan, Korea and Malaysia
- Younger ages had worse %-wise excess mortality than older ages in many countries
- Japan experienced the least impact overall

Excess deaths vs. healthcare access and quality



- Indication of negative correlation between excess deaths and HAQ index
- England & Wales seems to be an outlier
- Not adjusted for different age mix
- Only a preliminary exploration, study at bigger scale needed to draw any conclusion

STOCHASTIC MORTALITY MODEL

Two-parameter-level model

- Zhou, Rui, and Johnny Siu-Hang Li. "A multi-parameter-level model for simulating future mortality scenarios with COVID-alike effects." *Annals of Actuarial Science* 16.3 (2022): 453-477.

- The model: $\log m_{x,t} = a_x + b_x k_t + c_{x,t} \pi_t \mathbf{1}_{t \in \mathcal{T}}$

- k_t follows a random walk with drift such that $k_t = k_{t-1} + \mu + \epsilon_t, \quad \epsilon_t \overset{i.i.d.}{\sim} N(0, \sigma^2)$

- $\mathbf{1}_{t \in \mathcal{T}}$ is an indicator function with value of 1 if year t is a pandemic year

- An extension of the Lee-Carter model to account for pandemic shock

Two-parameter-level model

- The model: $\log m_{x,t} = a_x + b_x k_t + c_{x,t}\pi_t \mathbf{1}_{t\in\mathcal{T}}$
- a_x : long-term average log central death rate of age x over data period
- k_t : captures overall level of mortality improvement over time, a.k.a. the mortality index
- b_x : reflects age x's sensitivity to changes in k_t
- π_t : captures time-specific overall mortality shock in pandemic
- $c_{x,t}$: captures age-specific mortality impact, which also varies by time, relative to π_t

Simulation using two-parameter-level model

- Simulation model

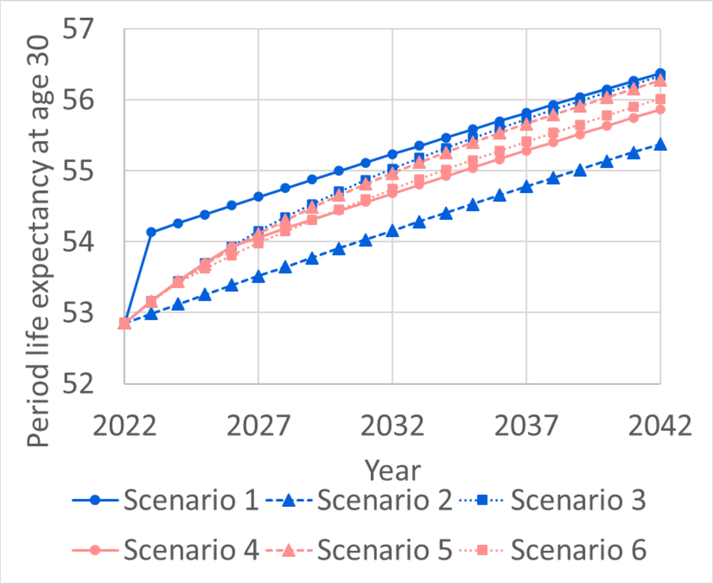
$$\log m_{x,t} = a_x + b_x k_t + \sum_i \Big(\underbrace{c_{x,t}^{(i)} \pi_t^{(i)} \mathbf{1}_{T_1^{(i)} \le t \le T_k^{(i)}}}_{\text{pandemic phase}} + \underbrace{c_{x,T_k}^{(i)} \pi_{T_k}^{(i)} \gamma^{g\left(t, T_k^{(i)}\right)} \mathbf{1}_{t > T_k^{(i)}}}_{\text{endemic phase}} \Big)$$

where $\mathbf{1}_t = \begin{cases} 1 \text{ with probability } p \\ 0 \quad\quad\quad\quad \text{otherwise} \end{cases}$ for any $t > T_k^{(1)}$

LONG-TERM MORTALITY IMPACT

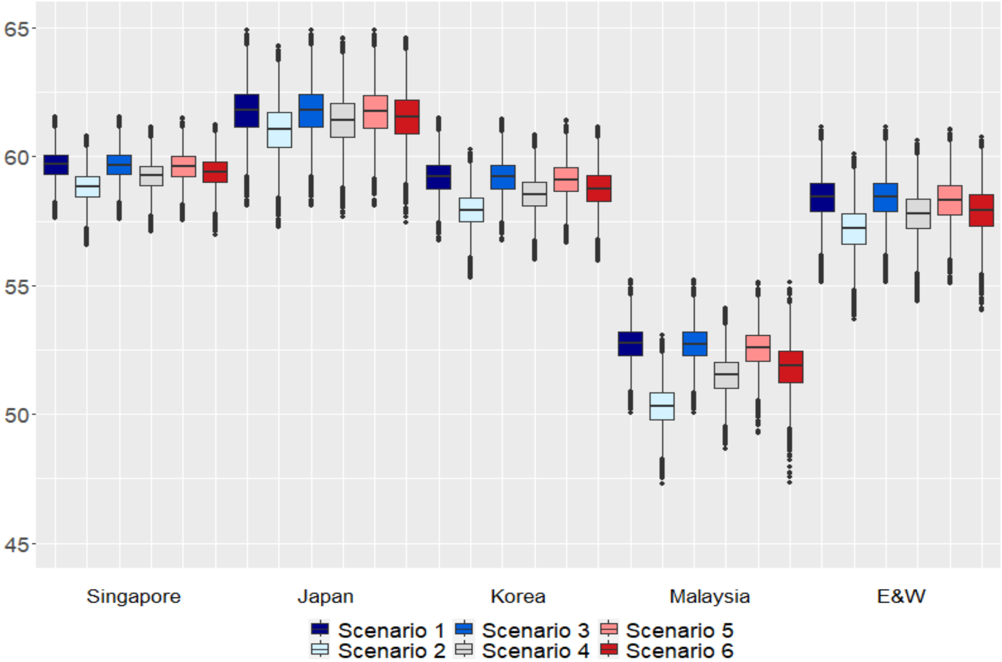
Simulation to forecast long-term mortality impact

- **Scenario 1**: COVID-19 mortality shock disappears completely and immediately, no new pandemic occurs
- **Scenario 2**: COVID-19 mortality shock continues indefinitely, no new pandemic occurs
- **Scenario 3**: COVID-19 mortality shock subsides gradually and indefinitely, no new pandemic occurs
- **Scenario 4**: COVID-19 mortality shock subsides gradually but only for 4 years, no new pandemic occurs
- **Scenario 5**: Scenario 3, plus a new pandemic occurs with a probability of 0.01 each year
- **Scenario 6**: Scenario 3, plus a new pandemic occurs with a probability of 0.05 each year



Mean of 10,000 Monte Carlo sample paths

Cohort life expectancy at age 30 in year 2032



- Indication of future lifetime of age 30 in 2032
- Scenarios assuming arrival of new pandemic (scenario 6) show significant left-tail risk (shorter life expectancy)
- Scenario 2-6 are plausible given historical long-term volatility: first and third quartile in Scenario 2-6 are within the data range of Scenario 1.
- Significant longevity risk in Singapore, Japan, Korea and E&W

IMPLICATIONS, RECOMMENDATIONS, LIMITATIONS AND CONCLUSIONS

Implications and recommendations

- Experience monitoring and data collection
- Mortality modelling
- Risk Management
- Protection gap
- Morbidity impact

Limitations

- Limitation of our stochastic mortality model: deterministic mortality shock and identical pattern in future pandemics
- Study based on population rather than insured lives data
- Study based on data up to 2022, longer-term monitoring necessary
- Morbidity impact not considered

Conclusion

- Do NOT close the book on COVID just yet

- Take another look and leave a bookmark

- Be vigilant about emerging trend in mortality and morbidity

- Be prepared for the next one