COVID-19
(Coronavirus)

Modelling Estimates for Bermuda and Potential impact of Non-Pharmaceutical Interventions (NPIS)

24 April 2020

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Disclaimer

- Numbers generated through this model cannot be interpreted as predictions of what will occur during a pandemic
- Provides estimates of what might happen, based on the assumptions and modeling strategy used
- Based on a simplified replication of the results of a more technical and sophisticated analysis
- Represents an attempt to provide decision makers with potentially useful but **heavily caveated** information

The purpose of the model is not to predict the future, it's to influence it, help us prepare for it and choose a good course of action.

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

About the model

- SEIR (Susceptible, Exposed, Infected, Recovered) model
- Based on the parameters in the Imperial College London (ICL) paper
  - Imperial College modelling report: Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand (16 March 2020)
  - https://www.imperial.ac.uk/media/imperial-college/medicine/sph/ide/gida-fellowships/Imperial-College-COVID19-NPI-modelling-16-03-2020.pdf
- Guidance from Public Health England (PHE)
  - UKOT COVID-19 Modelling Information Summaries (23 March 2020 and 16 April 2020)
    - Reproductive number (R_0 – the average number of secondary cases generated by a single infectious case) may vary based on country characteristics
    - R_0 of 2.4 recommended to monitor local situation (Worst Case Scenario)
- Inputs
- Bermuda population data and mortality rates
- Ongoing and to be refined as more information becomes available

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Assumptions

- Infectiousness
  - Symptomatic persons infectious from 12 hours prior to the onset of symptoms with peak infectivity of 2-6 days from symptom onset
  - Asymptomatic persons infectious from 4.6 days after infection
  - Symptomatic individuals 50% more infectious than asymptomatic individuals
- Recovery and immunity:
  - On recovery, individuals are immune to re-infection in the short term
- Hospitalization:
  - Mean duration from onset of symptoms to hospitalization of 5 days for those requiring hospitalization
  - Overall mean duration of hospitalization of 10.4 days
- Severity of cases varies by age
- Non-pharmaceutical interventions (NPIs) affect exposure by impacting the number of contacts for each case

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Non-Pharmaceutical Interventions (NPIs)

Non-Pharmaceutical Intervention (NPIs)	Description (when used alone)
Case Isolation in the home *Triggered by onset of symptoms and implemented immediately*	Symptomatic cases stay at home for **7** days, reducing non-household contacts by 75% for this period. Household contacts remain unchanged. Assume 70% of household comply with the policy.
Home Quarantine *Triggered by onset of symptoms and implemented immediately*	Following identification of a symptomatic case in the household, all household members remain at home for 14 days. Household contact rates double during this quarantine period, contacts in the community reduce by 75%. Assume 50% of household comply with the policy.
Closure of schools *Governmental decision*	Closure of all schools. Household contact rates for student families increase by 50% during closure. Contacts in the community increase by 25% during closure.
Social distancing of entire population *Governmental decision (consider surveillance triggers such as hospitalizations/critical care capacity)*	All households reduce contact outside household, school or workplace by 75%. School contact rates unchanged, workplace contact rates reduced by 25%. Household contact rates assumed to increase by 25%.
Social distancing of the most vulnerable *Governmental decision (consider surveillance triggers such as hospitalizations/critical care capacity)*	Reduce contacts by 50% in workplaces, increase household contacts by 25% and reduce other contacts by 75%. Assume 75% compliance with policy.

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Potential impact of NPIs

- In combination, NPIs are predicted to reduce peak critical care demand by two-thirds and halve the number of deaths
- NPIs should be maintained or transmission may rapidly rebound
- Impact of NPIs influences the timeline
  - **2-3 week** lag between introduction and impact of NPIs
- No easy policy decision to be made
- Ethical and economic implications should be considered

COVID-19
(Coronavirus)

Strategies

- 2 strategies evaluated using same NPIs
  - Suppression
    - Reduce the reproduction number, R, to below 1
    - Reduce case numbers to low levels or eliminate human-to-human transmission
    - NPIs (and drugs, if available) need to be maintained – at least intermittently - for as long as the virus is circulating in the human population, or until a vaccine becomes available (12-18 months, varying efficacy)
  - Mitigation
    - Slow spread by reducing R, but not to below 1
    - Reduce the health impact of an epidemic
    - Population immunity builds up through the epidemic, leading to an eventual rapid decline in case numbers and transmission dropping to low levels
    - Interventions need to remain in place for as much of the epidemic period as possible
- Overall goal to reduce reproduction number to ≈1 or just below 1

COVID-19
(Coronavirus)

Implications of each strategy

- Suppression
  - Enormous social and economic costs
  - Significant impact on health and well-being in the short and longer-term
  - The more successful a strategy is at temporary suppression, the larger the later epidemic is predicted to be in the absence of vaccination, due to lesser build-up of herd immunity
- Mitigation
  - Never able to completely protect those at risk from severe disease or death
  - Resulting mortality may still be high
  - Introducing such interventions too early risks allowing transmission to return once they are lifted (if insufficient herd immunity has developed)
  - Necessary to balance the timing of introduction with the scale of disruption imposed and the likely period over which the interventions can be maintained
  - Interventions can limit transmission to the extent that little herd immunity is acquired – leading to the possibility that a second wave of infection is seen once interventions are lifted

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

PHE Considerations

- Bermuda:
  - Slightly older population, poorer outcomes in persons with Afro-Caribbean heritage
- Combinations of social and behavioural interventions significantly reduce community contacts outside of households impacting the epidemic
  - Strong interaction between interventions
  - Difficult to model the effects of removing any one intervention
  - Combined interventions reduce the reproductive number to ≈1 or just below 1
    - Results in prolonged lower level outbreaks that would last many months
- Wider social distancing/lockdown is an appropriate measure to control strong epidemics
  - Such control measures take up to 10 days to have any evident effect and a further 10 days to show peak effect
- Optimum length of time for implementation of such measures unlikely to be less than 4-6 weeks in most cases.

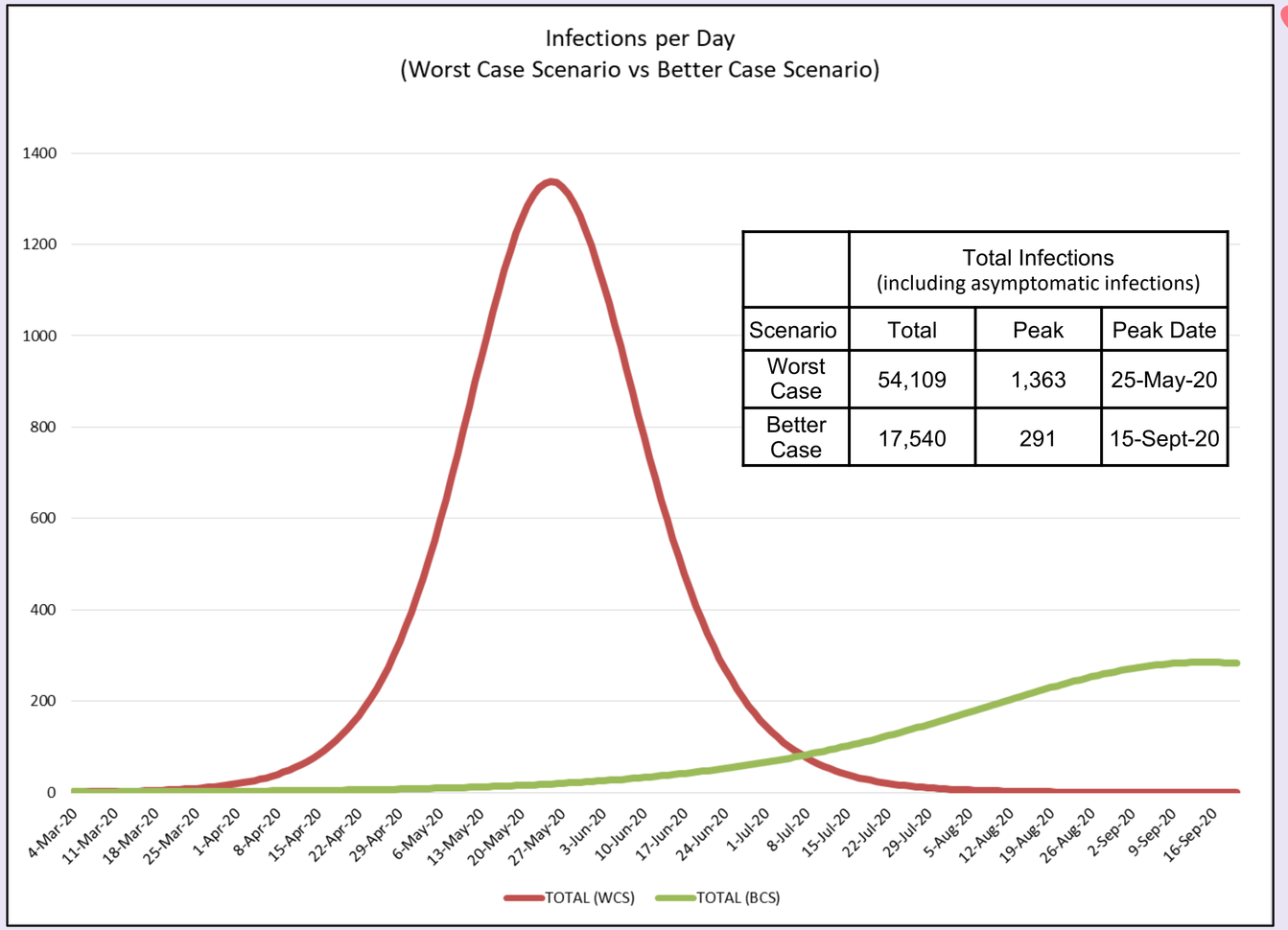
COVID-19
(Coronavirus)

Bermuda Modelling

- For simplicity, modelled at a constant reproductive number
  - Worst case scenario – Reproductive number of 2.4
  - Better case scenario – Reproductive number of 1.4
    - Creates results most similar to ICL model reflecting impact of combined NPIs
      - Remodelling to occur when ICL releases full code with assistance from PHE
- For simplicity, modelled at a constant reproductive number
  - Local real-time data and intelligence crucial to assess local situation and impact on healthcare capacity
  - Estimates of timeline and characteristics of cases must be reviewed based on local situation

COVID-19
(Coronavirus)

Bermuda Modelling: Infections per day



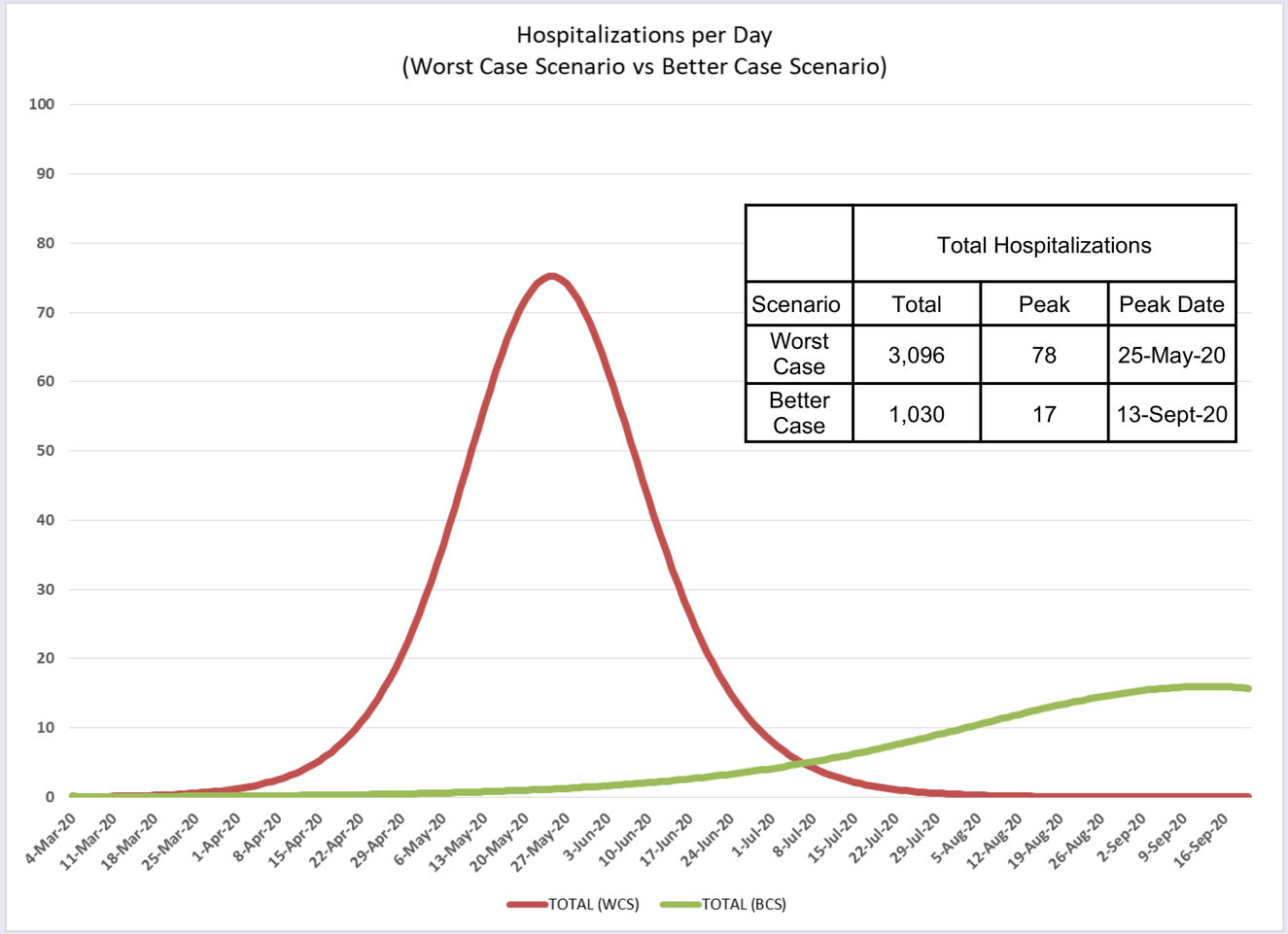
	Total Infections (including asymptomatic infections)		
Scenario	Total	Peak	Peak Date
Worst Case	54,109	1,363	25-May-20
Better Case	17,540	291	15-Sept-20

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Bermuda Modelling: Hospitalizations per day

- Hospitalization rate varies by age
  - 0.1% in under 10s - 27.3% in over 80s



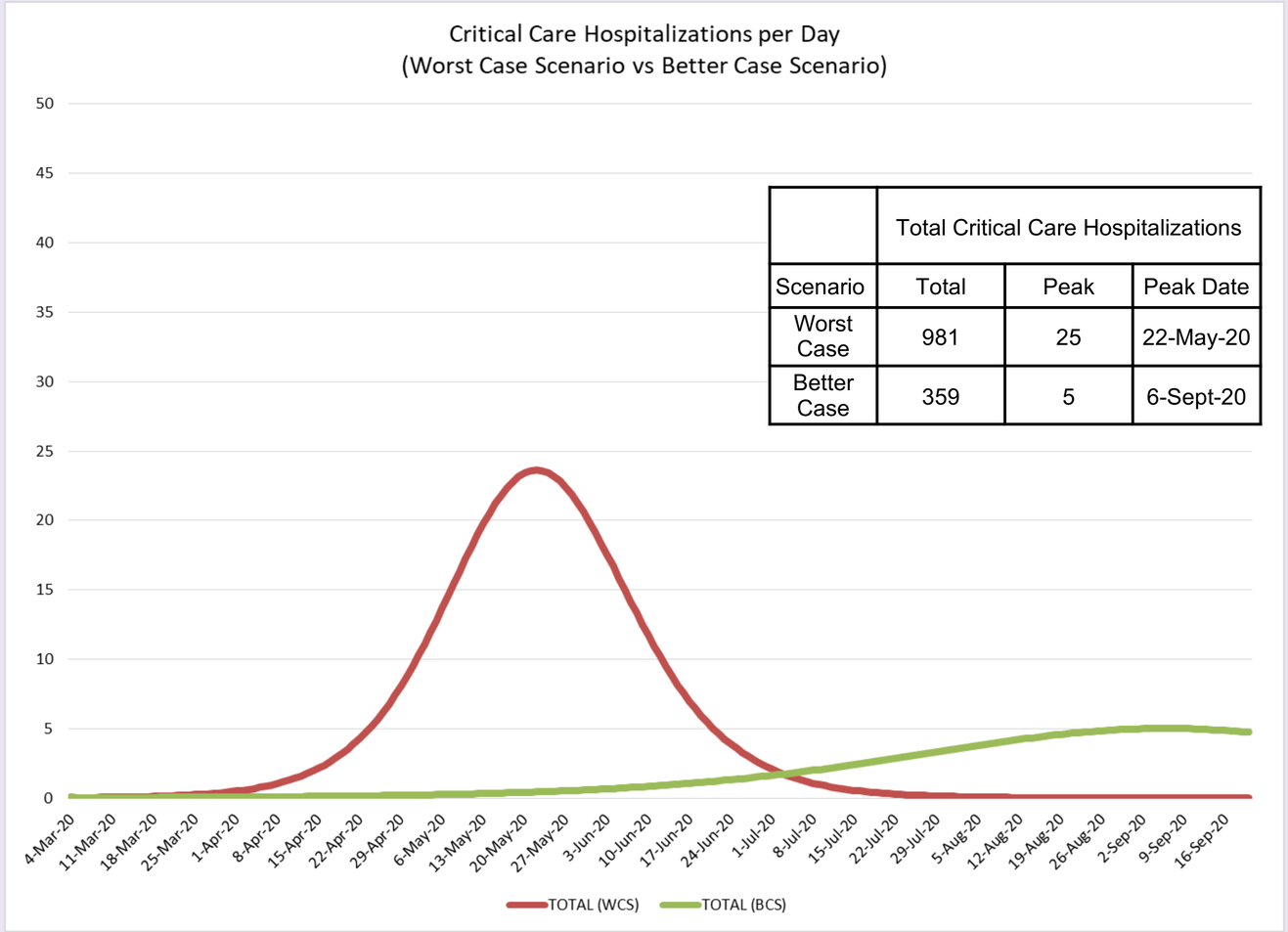
	Total Hospitalizations		
Scenario	Total	Peak	Peak Date
Worst Case	3,096	78	25-May-20
Better Case	1,030	17	13-Sept-20

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Bermuda Modelling: Critical care hospitalizations per day

- Critical Care Hospitalization rate varies by age
- 5.0% in under 10s - 70.9% in over 80s



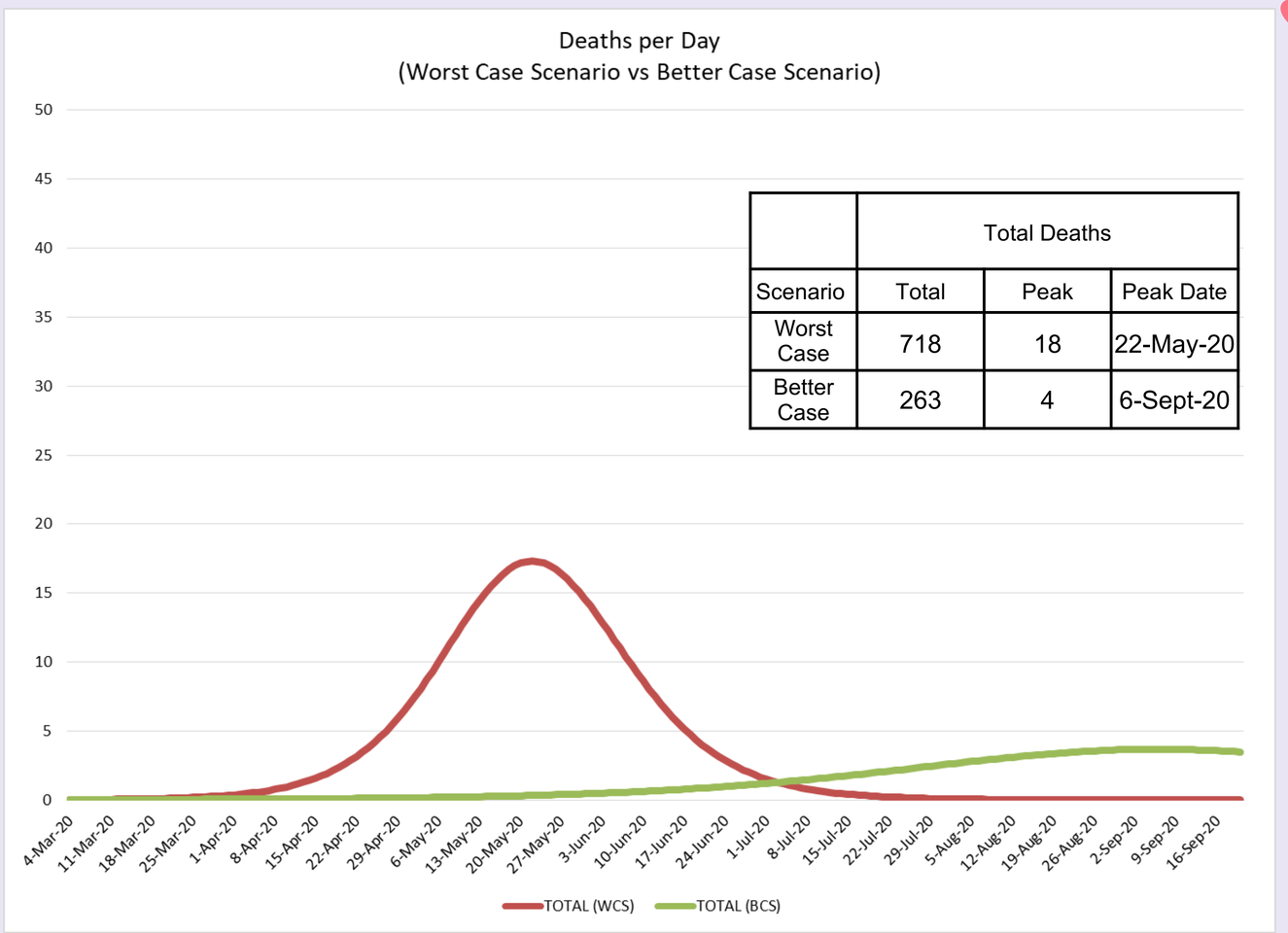
	Total Critical Care Hospitalizations		
Scenario	Total	Peak	Peak Date
Worst Case	981	25	22-May-20
Better Case	359	5	6-Sept-20

GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Bermuda Modelling: Deaths per day

- Infection Fatality Ratio varies by age
- 0.002% in under 10s - 9.3% in over 80s



	Total Deaths		
Scenario	Total	Peak	Peak Date
Worst Case	718	18	22-May-20
Better Case	263	4	6-Sept-20

GOVERNMENT OF BERMUDA
Ministry of Health

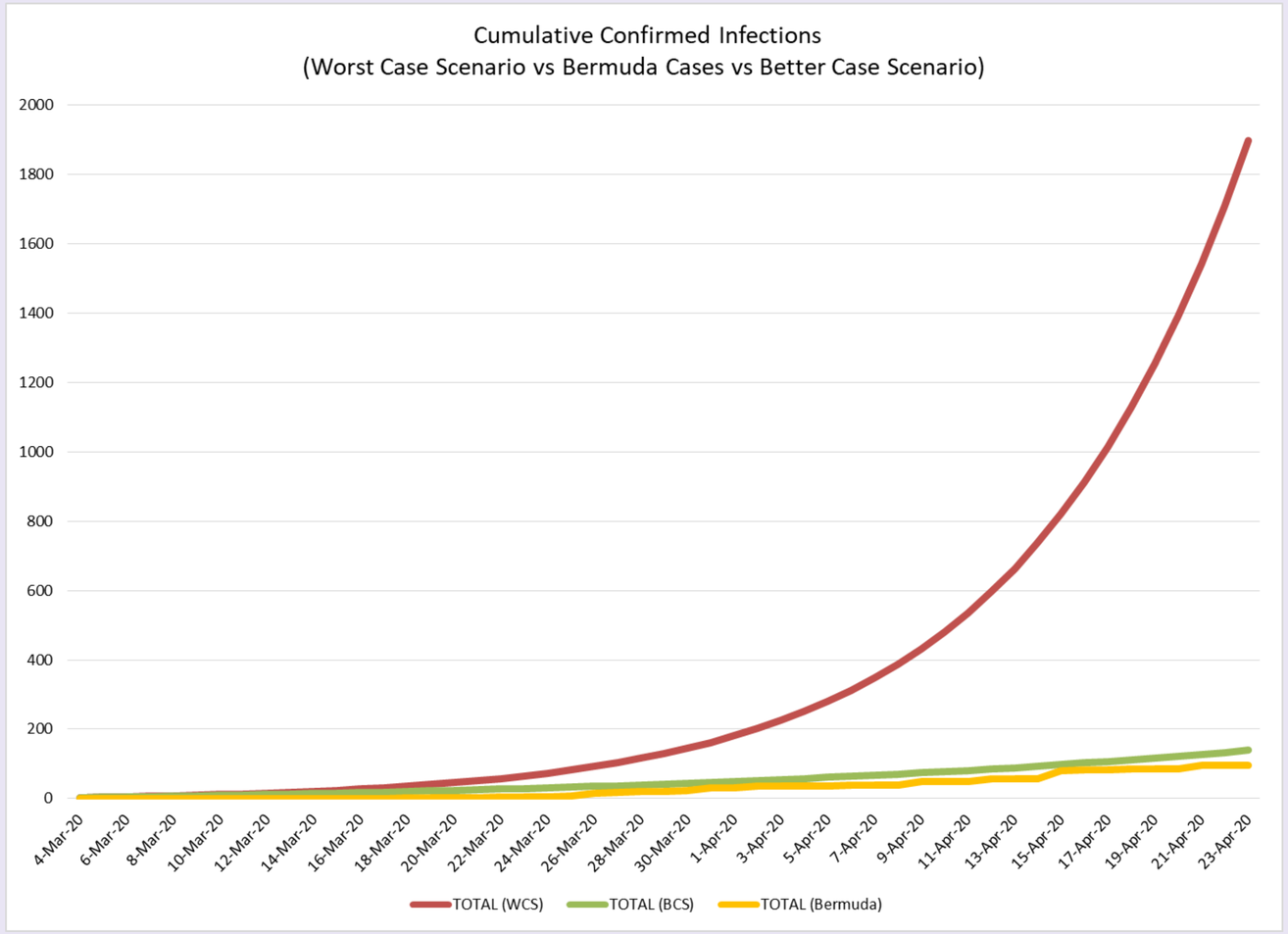
COVID-19
(Coronavirus)

Recommendations from ICL model

- An **adaptive policy** in which social distancing is only initiated after pre-determined trigger(s)
  - ICL Suggestion: “on” and “off” thresholds based on weekly confirmed case incidence in ICU patients (a group of patients highly likely to be tested)
- Case-based policies of isolation of symptomatic cases and household quarantine of high-risk contacts continue
- Necessary to layer multiple interventions for duration of pandemic to avoid rebound
  - Choice of interventions ultimately depends on **relative feasibility** of their implementation and **likely effectiveness** in different social contexts
  - Difficult to be definitive about the duration of measures which will be required
  - Decisions on when and for how long to relax policies will need to be informed by ongoing surveillance

COVID-19
(Coronavirus)

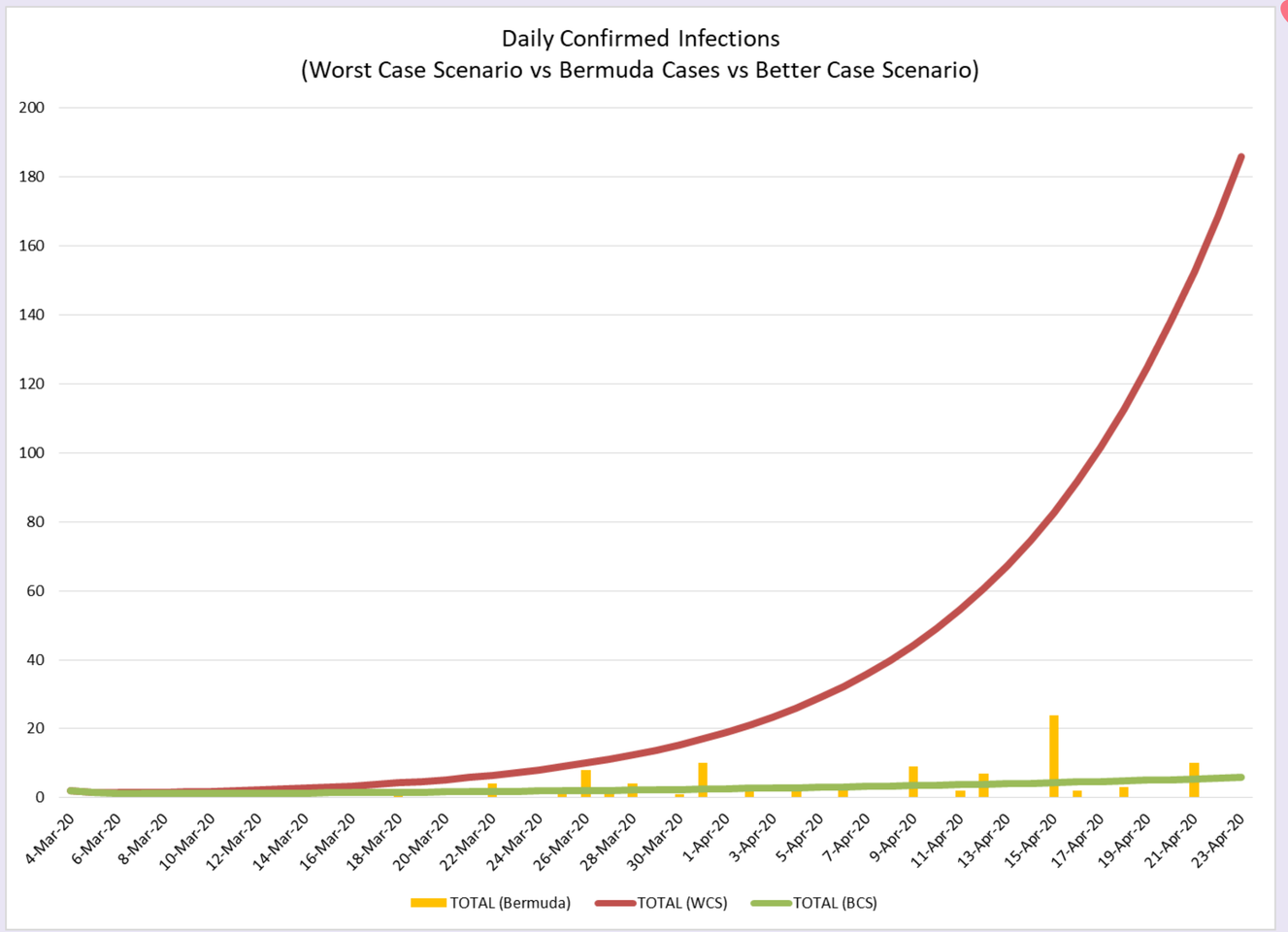
Bermuda Comparison: Infections (Cumulative)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

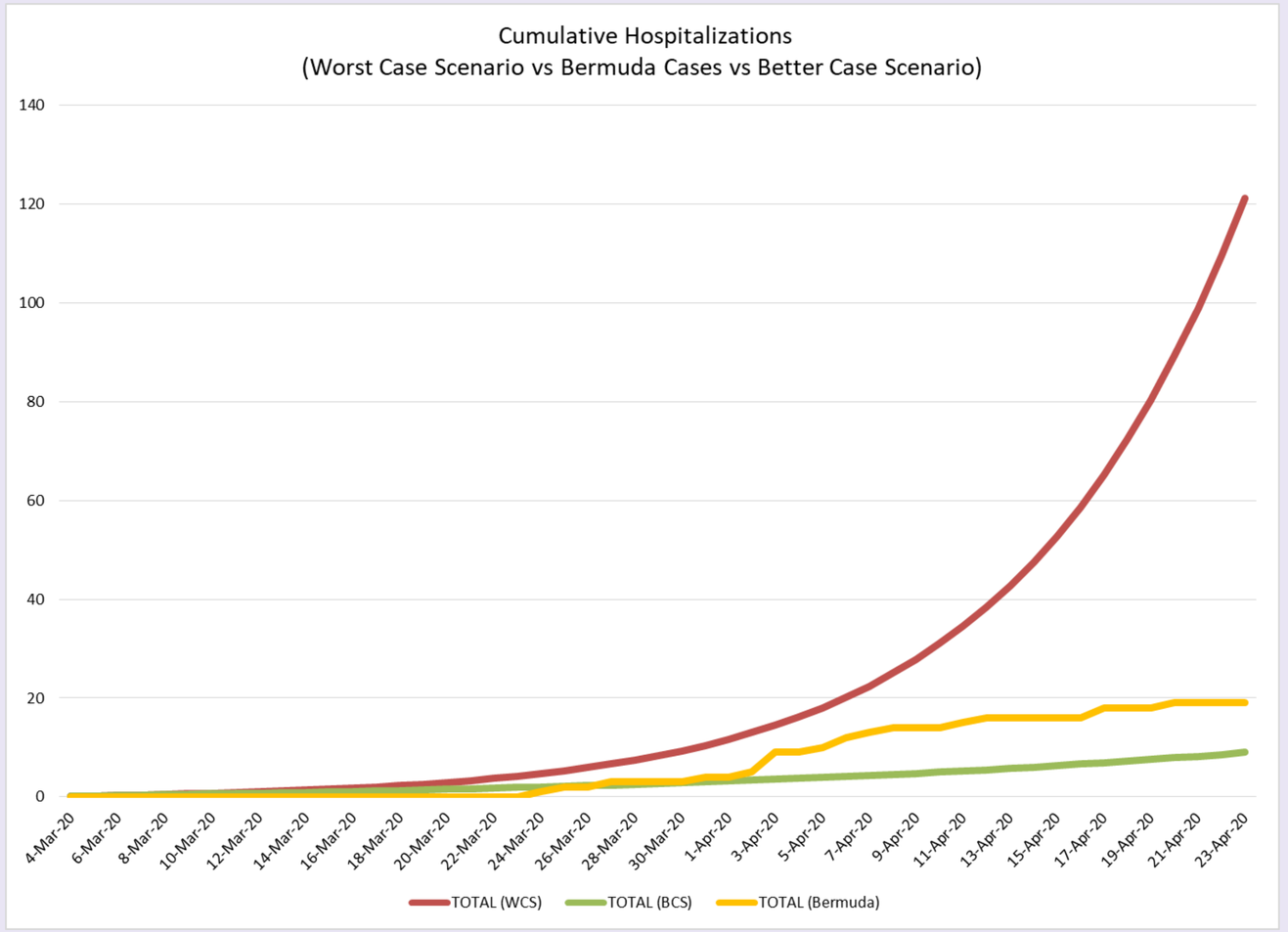
Bermuda Comparison: Infections (Daily)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

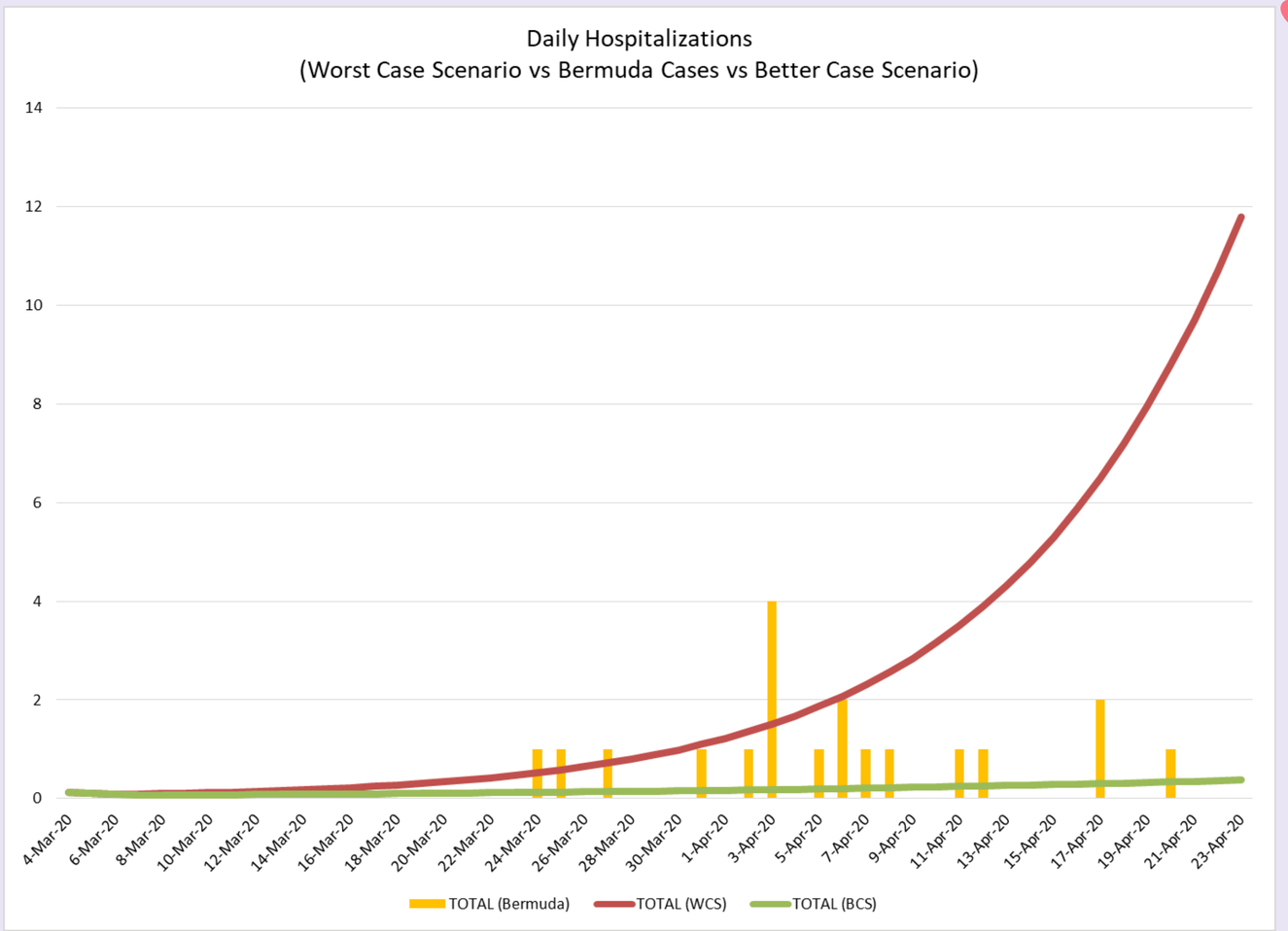
Bermuda Comparison: Hospitalizations (Cumulative)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

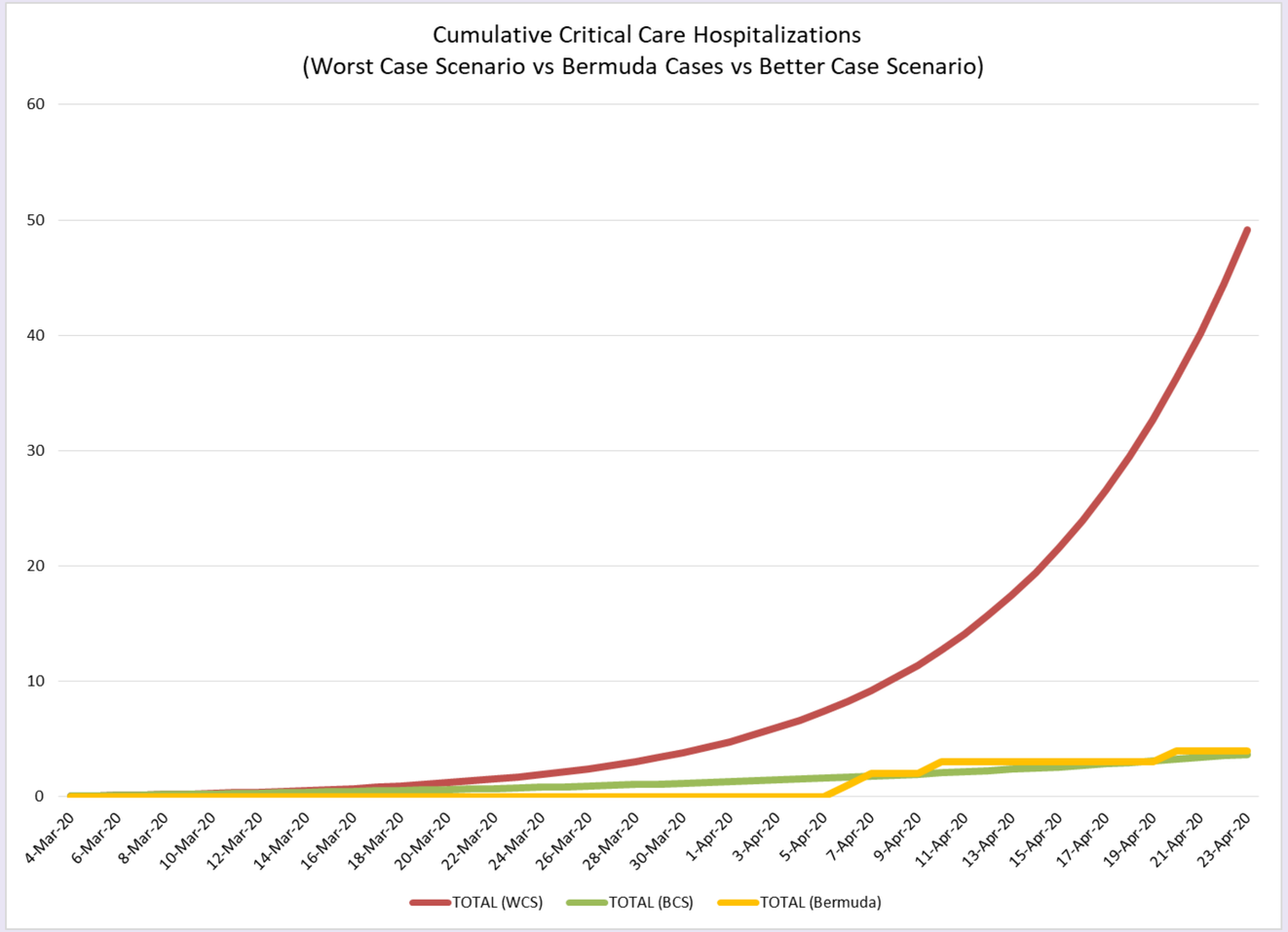
Bermuda Comparison: Hospitalizations (Daily)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

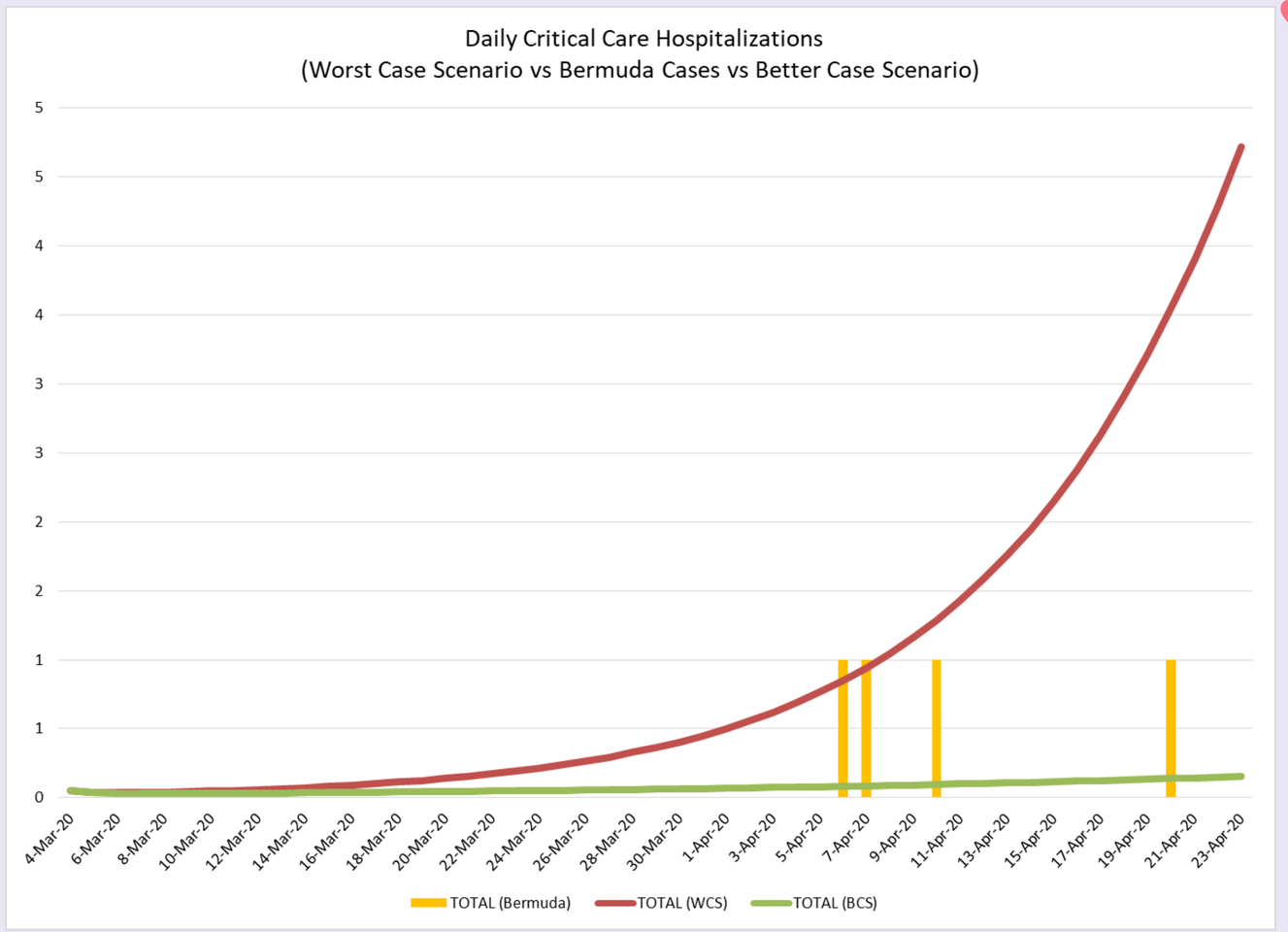
Bermuda Comparison: Critical Care Hospitalizations (Cumulative)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

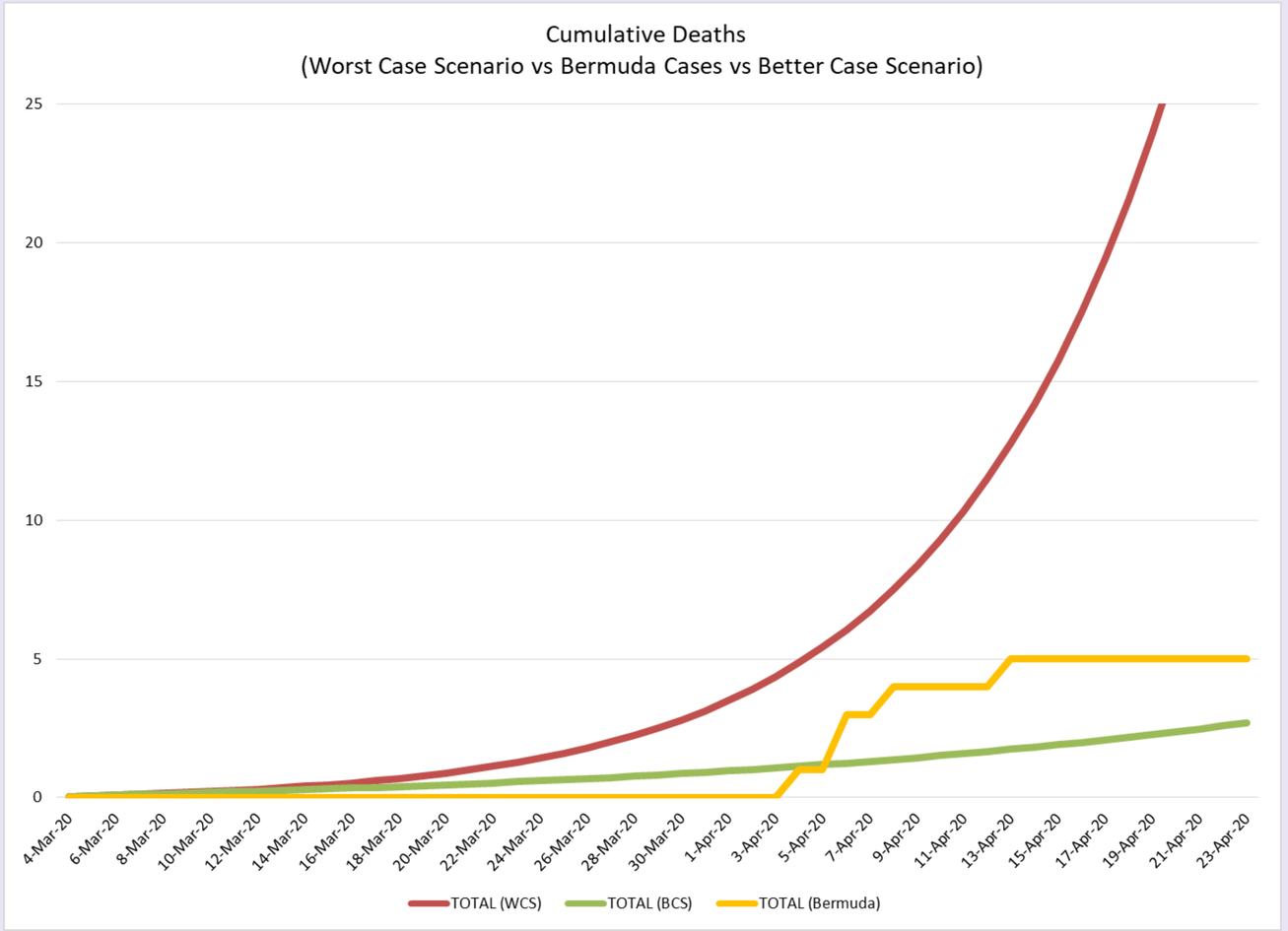
Bermuda Comparison: Critical Care Hospitalizations (Daily)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

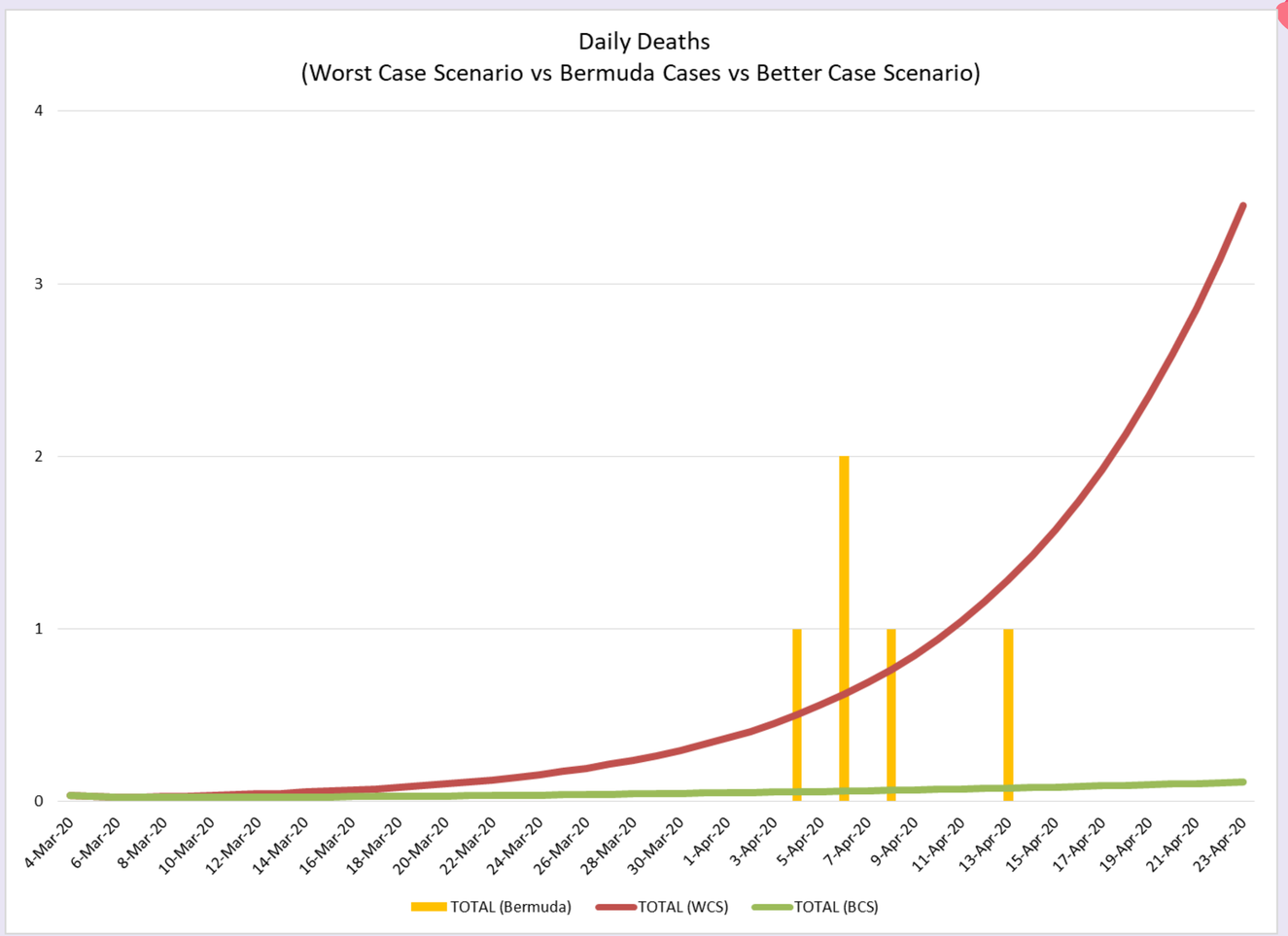
Bermuda Comparison: Deaths (Cumulative)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Bermuda Comparison: Deaths (Daily)



GOVERNMENT OF BERMUDA
Ministry of Health

COVID-19
(Coronavirus)

Conclusions

- Imperial College London:
  - Early action is important, and interventions need to be in place well before healthcare capacity is overwhelmed
  - Measures should adapt and evolve based on local surveillance information (triggers) to reduce healthcare demand and mortality
  - The social and economic effects of the measures which are needed to achieve this policy goal will be profound
- Public Health England:
  - Rapid case identification, case-isolation, and contact tracing/isolation must remain the mainstay of management
  - Crucial to continue enhanced surveillance and ensure health services are on high alert to rapidly identify suspected cases, isolate them and their households effectively and to rapidly trace and isolate contacts of any cases
- World Health Organization (16 April 2020)
  - The most plausible scenario may involve **recurring waves interspersed with periods of low-level transmission**
    - From: Interim Guidance: Considerations in adjusting public health and social measures in the context of COVID-19 accessed 20 April 2020