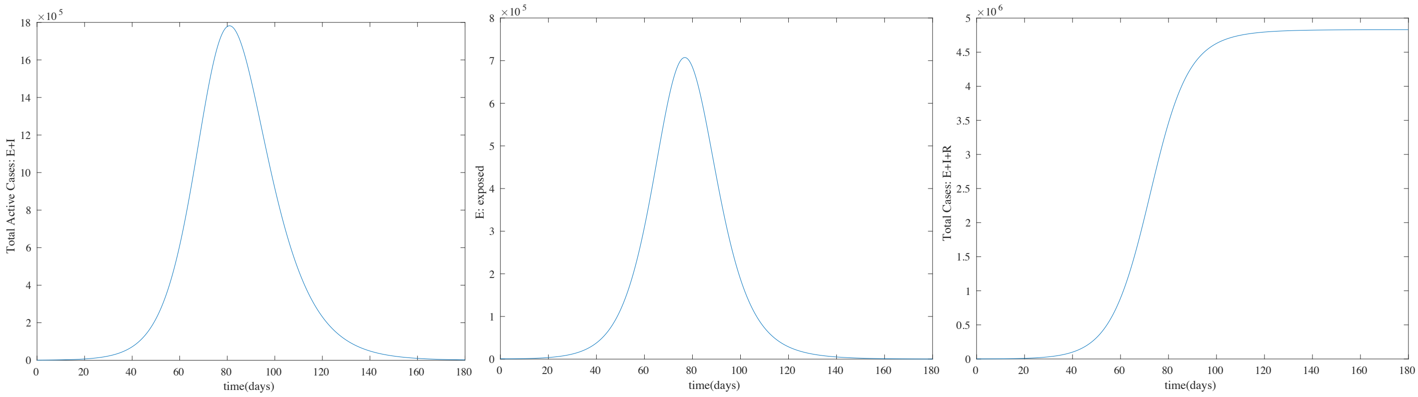
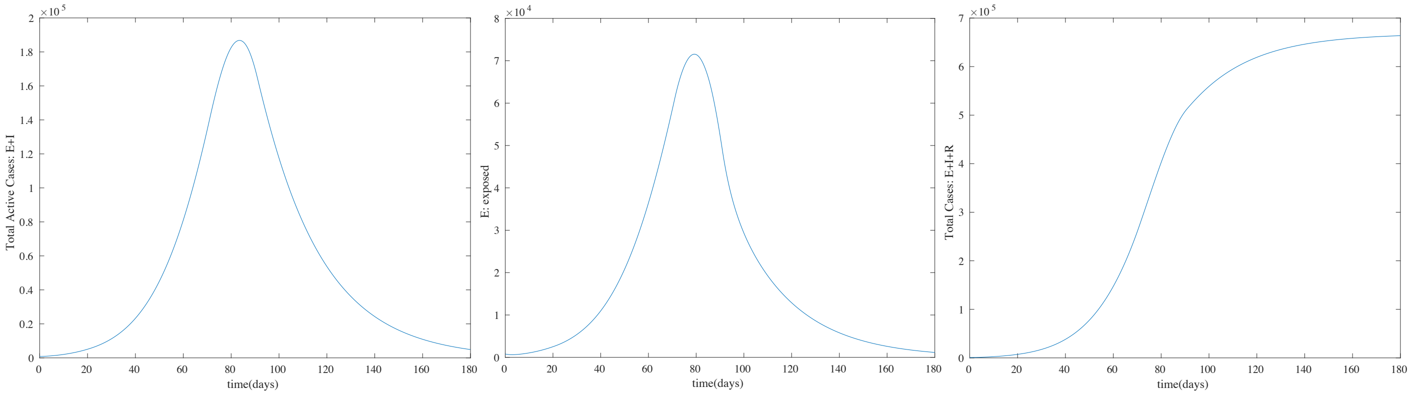
Scenario 1



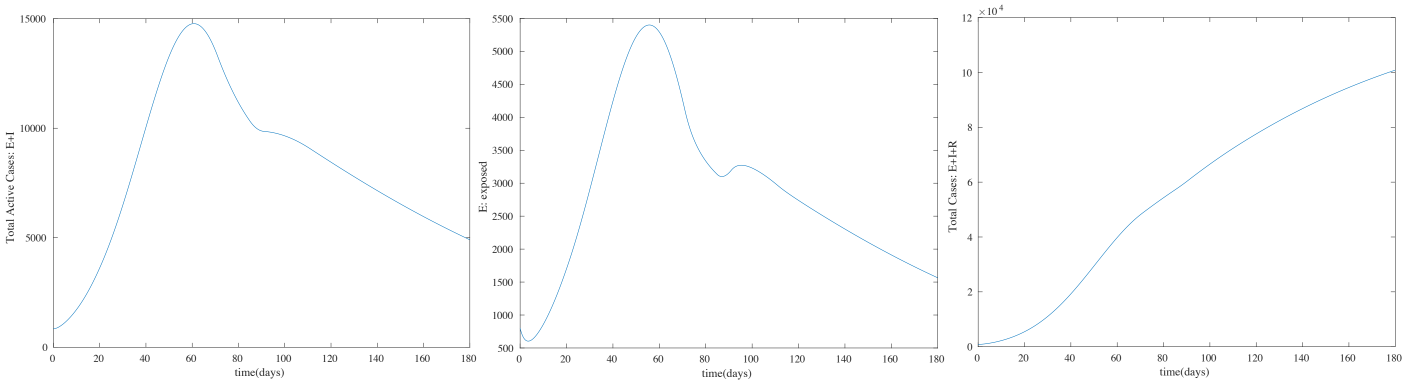
In Scenario 1, when $R_0 = 3.5$, number of total active cases arises rapidly and reaches highest 1781977 around Day 81. Number of exposed people reaches its maxima 707252 at Day 77. After peak period, number of both active cases and exposed people decline quickly, which is shown in the graph of total cases as well. Finally, at Day 180, total cases reach 4829677 with an exponential growth, which is the most serious case among these scenarios. Among these individuals, there are 198 exposed and 1864 infected. The majority of these people 4827616 are recovered, which is the highest amount of recovered cases among these scenarios as well, and 170323 individuals are susceptible.

Scenario 2



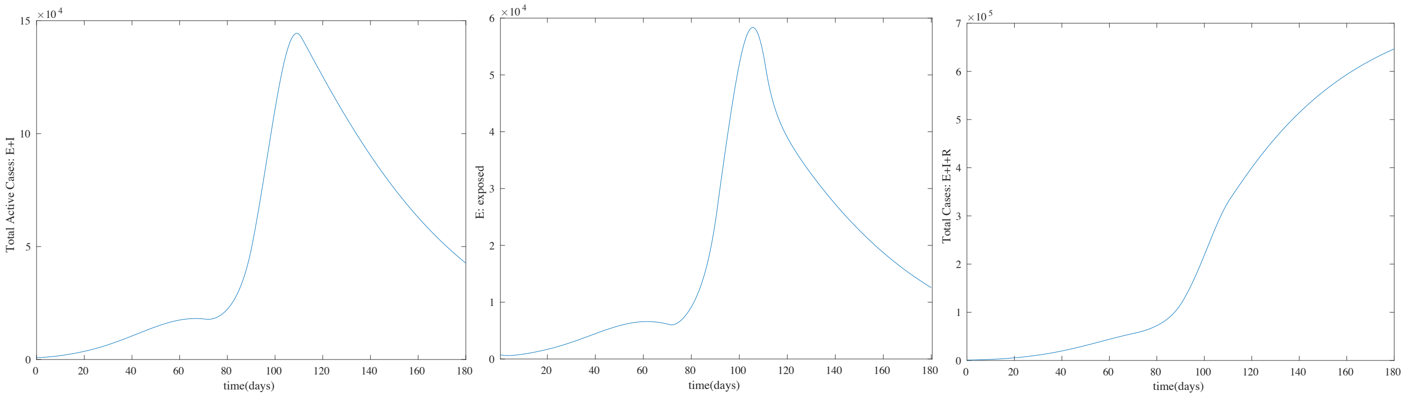
In Scenario 2, which corresponds to a scenario with some lock-down measures, R_0 varies from 3.5 to 0.5 and gradually decreases. Number of exposed people reaches its maxima 71554 at Day 79, which is much lower than that in Scenario 1. After peak period, number of both active cases and exposed people decline quickly, but not so quickly as it is in the previous scenario as well. Hence, the number of total cases does not increase rapidly after the peak period. At Day 180, number of total cases reaches 663725. Among these individuals, there are 1161 exposed and 3733 infected. The majority of people 4336275 are susceptible, and 658831 are recovered. It is shown that the lock-down measures really work.

Scenario 3



In Scenario 3, which corresponds to an effective response, R_0 decreases from 3 to 0.8 until Day 90 but slightly increases to 1 during the period from Day 91 to 110, and gradually decreases to 0.5 as well. In this scenario, number of exposed people reaches its maxima 5401 at Day 56, and number of active cases reaches 14775 at Day 61, which is the lowest among these scenarios. However, there is a small bounce from Day 87 to 95 because of increase on R_0. The number of total cases develops with a linear growth, which reaches 100842 finally. Among these, there are 1564 exposed and 3342 infected. There are 4899158 susceptible individuals and 95936 recovered in the end. Obviously, an effective response contributes to a positive consequence that Scenario 3 has least total cases.

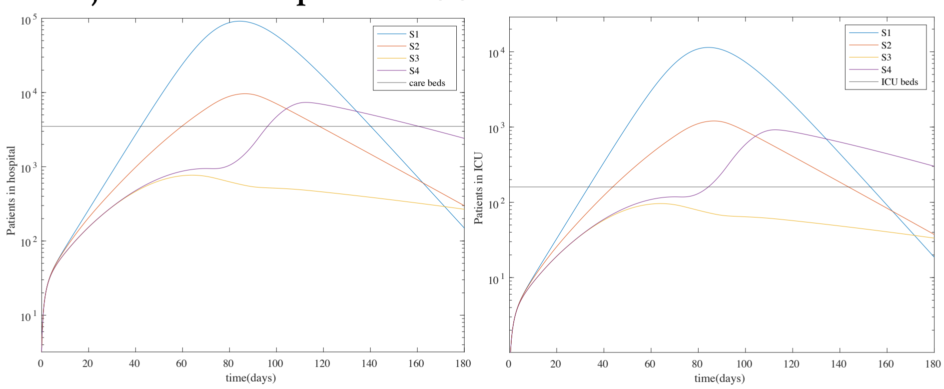
Scenario 4



In Scenario 4, which is the model of allowing a lapse in prevention measures, R_0 varies from 3 to 0.9 quickly with in first 80 days, but grows rapidly to 3.2 until Day 110. As a result, number of exposed people reaches its maxima 58345 at Day 106, and number of active cases reaches its maxima 144418 at Day 109. Number of active cases remains relative low until Day 80, and there is a drastic increase then due to the lapse in prevention. As a result, at Day 180, number of total cases reaches 646554. Among these, 12557 individuals are exposed, and 30112 are infected. Besides, there are 4353446 individuals susceptible and 603886 recovered. Compared to Scenario 2, the total cases and recovered individuals are approximately same, while numbers of exposed and infected people in Scenario 4 are much higher.

Deaths, Patients in hospital and ICU

Scenario	Deaths per 1 million
1	38621
2	5271
3	767
4	4831



Among these four scenarios, if we take a closer look at deaths, patients in hospital and ICU, we can find that Scenario 1 is the most severe case. In Scenario 1, there are 38621 death cases per one million people, and it is also the first to exceeds the capacity of hospital and ICU, at Day 42 and Day 34 relatively. On contrast, it is obvious that Scenario 3 is the only case that the condition is always under control. Numbers of patients in both hospital and ICU keep within the limits of medical resources, and number of deaths per one million people 3828 is also the lowest. Scenario 2 and 4 have approximately same death cases per one million people, 5271 and 4831, but Scenario 2 has a faster approach. This tendency is also represented in the graph of patients in hospital and ICU. Scenario 2 is the second to exceed the capacity at Day 60 and 44 relatively, which is only a better condition than Scenario 1. Due to lock down measures, it is also the first to bring number of patients back to within the capacity of hospital and ICU except for Scenario 3.Because of the lapse in prevention, Scenario 4 becomes the only case that ICUs remain scarce at Day 180, and it is also the last to make hospital available for more patients.

```
par.N = 5e+6;
par.alpha = 1./5.2;
par.gamma = 1./10;
par.rzero = 3.5;

yinit = zeros(4,1);
yinit(2) = 800;
yinit(3) = 40;
yinit(4) = 0;
yinit(1) = par.N - 800 -40;
rtol = 1.e-6; atol=1.e-5;
options = odeset('AbsTol',
atol,'RelTol',rtol,'MaxOrder',5);

[t,y] = ode45(@(t, y) seir(t,y, par) ,[0,180], yinit,
options);
total_cases(:,1) = y(:,2) + y(:,3) + y(:,4);

% Scenario 1
% deaths
death = zeros(4,1);
death(1) = y(length(y),4)*0.04/5;

% hospital
h = figure;
plot(t,y(:,3)*0.08);
xlabel('time(days)');
ylabel('Patients in hospital');

% ICU
i = figure;
plot(t,y(:,3)*0.01);
xlabel('time(days)');
ylabel('Patients in ICU');

% Active cases
figure;
plot(t, y(:,2) + y(:,3));
xlabel('time(days)');
ylabel('Total Active Cases: E+I');

% Exposed
figure;
plot(t, y(:,2));
xlabel('time(days)');
ylabel('E: exposed');

% Total cases
figure;
plot(t, total_cases(:,1));
xlabel('time(days)');
ylabel('Total Cases: E+I+R');

% Scernario 2
par.rzero = 0;
par.rtable = [ 1 3.5; 21 2.6; 71 1.9; 85 1.0; 91 0.55;
1001 0.5];
[t,y] = ode45(@(t, y) seir(t,y, par) ,[0,180], yinit,
options);
clear total_cases
total_cases(:,1) = y(:,2) + y(:,3) + y(:,4);

% deaths
death(2) = y(length(y),4)*0.04/5;

% hospital
figure(h);
hold on
plot(t,y(:,3)*0.08);

% ICU
figure(i);
hold on
plot(t,y(:,3)*0.01);

% Active cases
figure;
plot(t, y(:,2) + y(:,3));
xlabel('time(days)');
ylabel('Total Active Cases: E+I');

% Exposed
figure;
plot(t, y(:,2));
xlabel('time(days)');
ylabel('E: exposed');

% Total cases
figure;
plot(t, total_cases(:,1));
xlabel('time(days)');
ylabel('Total Cases: E+I+R');

% Scernario 3
par.rtable = [ 1 3; 21 2.2; 71 0.7; 85 0.8; 91 1; 111 0.9;
1001 0.5];
```

```
[t,y] = ode45(@(t, y) seir(t,y, par) ,[0,180], yinit, options);
clear total_cases
total_cases(:,1) = y(:,2) + y(:,3) + y(:,4);

% deaths
death(3) = y(length(y),4)*0.04/5;
% hospital
figure(h);
hold on
plot(t,y(:,3)*0.08);
% ICU
figure(i);
hold on
plot(t,y(:,3)*0.01);

% Active cases
figure;
plot(t, y(:,2) + y(:,3));
xlabel('time(days)');
ylabel('Total Active Cases: E+I');
% Exposed
figure;
plot(t, y(:,2));
xlabel('time(days)');
ylabel('E: exposed');
% Total cases
figure;
plot(t, total_cases(:,1));
xlabel('time(days)');
ylabel('Total Cases: E+I+R');

% Scernario 4
par.rtable = [ 1 3; 21 2.2; 71 0.9; 85 2.5; 91 3.2; 111 0.85; 1001 0.5];
[t,y] = ode45(@(t, y) seir(t,y, par) ,[0,180], yinit, options);
clear total_cases
total_cases(:,1) = y(:,2) + y(:,3) + y(:,4);

% Deaths
death(4) = y(length(y),4)*0.04/5;
% hospital
figure(h);
hold on
plot(t,y(:,3)*0.08);
set(gca, 'YScale', 'log');
ylim([0 1e+5]);
yline(3500);
legend('S1','S2','S3','S4','care beds');
% ICU
figure(i);
hold on
plot(t,y(:,3)*0.01);
set(gca, 'YScale', 'log');
ylim([0 inf]);
yline(160);
legend('S1','S2','S3','S4','ICU beds');

% Active cases
figure;
plot(t, y(:,2) + y(:,3));
xlabel('time(days)');
ylabel('Total Active Cases: E+I');
% Exposed
figure;
plot(t, y(:,2));
xlabel('time(days)');
ylabel('E: exposed');
% Total cases
figure;
plot(t, total_cases(:,1));
xlabel('time(days)');
ylabel('Total Cases: E+I+R');

function    yprime = seir(t,y, par)
    if par.rzero == 0
        rtable = par.rtable;
        t_val = max( rtable(1,1), min( t, rtable(length(rtable),1)) );
        R_zero = interp1( rtable(:,1), rtable(:,2), t_val);
    else
        R_zero = par.rzero;
    end
    alpha = par.alpha;
    gamma = par.gamma;
    beta = R_zero.*gamma;
    N = par.N;

    yprime = zeros(4,1);
    yprime(1) = -beta*y(1)*y(3)/N;
    yprime(2) = +beta*y(1)*y(3)/N - alpha*y(2);
    yprime(3) = +alpha*y(2) -gamma*y(3);
    yprime(4) = gamma*y(3);
end
```