MRC Centre for Global Infectious Disease Analysis

Strategies for long-term management of COVID-19 transmission

Imperial College COVID-19 response team

[redacted]

Aims: examine strategies which allow social distancing to be relaxed, school closure to be ended, but keep transmission suppressed (i.e. keep incidence of deaths, ICU cases substantially below current peak). Examination of app-based contact tracing is a secondary objective.

Policies:

- Assume policy switch in the last week in May (except schools, in some scenarios).
- Continued case isolation in the home (90% compliance), household quarantine (75% compliance).
- Reduced social distancing (work contacts at 75% of normal, social at 50% of normal).
- Examine schools reopening after May half-term, or in September.
- Reactive school closure for 2 weeks when a case is detected in a pupil or staff member.
- Tracing of contacts of symptomatic index case (manual and/or app-based).
- Tracing of contacts of contacts of symptomatic cases. Note that this can only likely be achieved with technology, so the coverage assumed here would require distribution of phones to current non-users. The number of contacts being isolated under such policies is underestimated by our simulation, as it only tracks contacts of infectious individuals.
- Isolation outside the home. A significant fraction of exposed individuals are isolated in quarantine centres in Korea, especially if they are unable to fully isolate in the home, or live with vulnerable individuals.

Transmission/infectiousness scenarios

- Default – as prior modelling
- PreSymp – higher level of presymptomatic transmission (1.5 days, 1/3 of all transmission).
- MoreSocial – lower level of household (27%) and school/workplace transmission (27%), more in other social contexts. PreSymp infectiousness scenario also assumed.
- LoKids – higher asymptomatic fraction overall (50%+) and children less susceptible (0-5 – 70%; 5-10 – 80%; 10-15 – 90%, >15 – 100%) and symptomatic susceptible (0-5 – 20%; 5-10 – 30%; 10-15 – 40%, >15 – 50%). This scenario also has an IFR reduced by ¼.

Other

- R_0 values of 2.8, 3 and 3.2 examined
- Contact tracing modelling tuned to give a mean of ~20 contacts per index case (excl. household).
- Contacts distributed between general social mixing and schools/workplaces.
- Household members assumed to be contacts.
- Testing sensitivity/specificity can be included.
- Age dependent severity included.
- OFCOM data used to parameterise smartphone ownership (~65% in whole population, assuming <16s are not app users).
- Numbers of contacts isolated under recursive tracing scenarios are underestimated, as simulation only tracks contacts of infectious individuals.

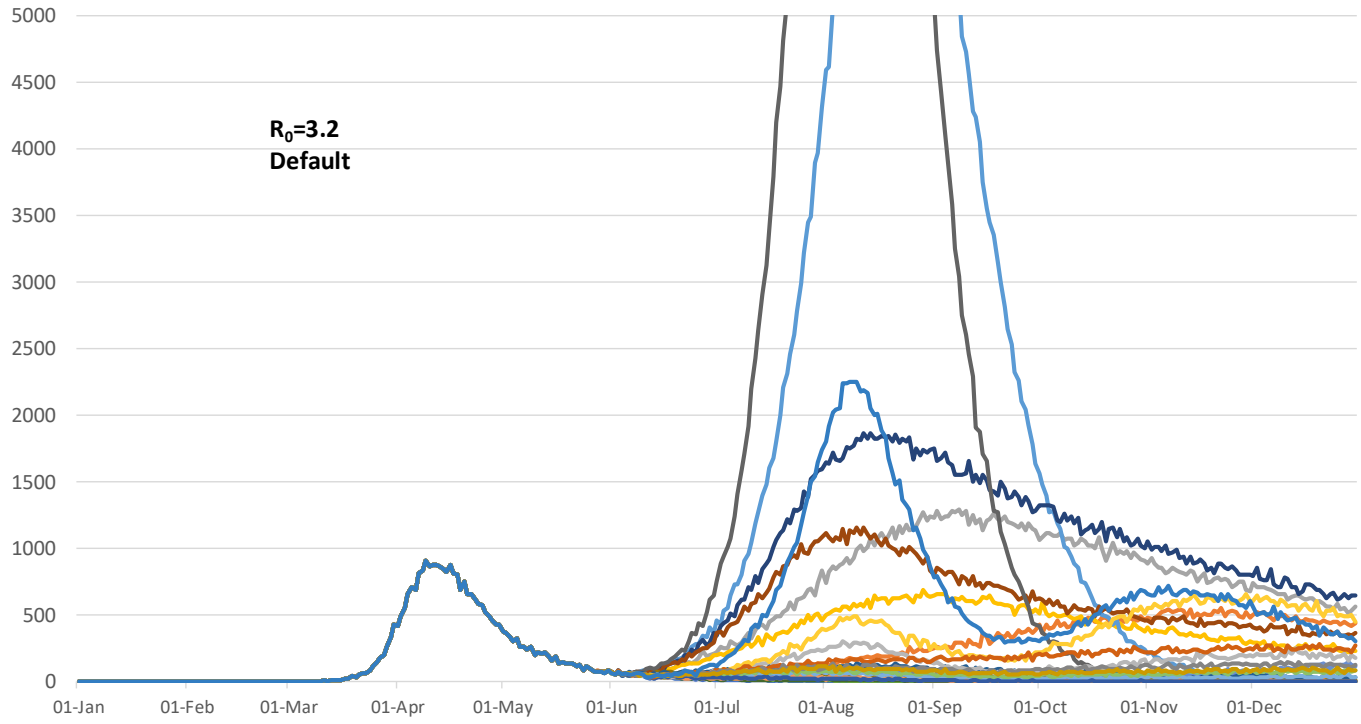
Conclusions

- Substantial though reduced social distancing will need to be kept in place for schools and workplaces to open. We examined a scenario here where social contacts are maintained at 50% of pre-lockdown levels.
- High compliance case isolation and household quarantine will be essential – likely aided by mass testing.
- Rapid (<2 days) contact tracing and isolation of 80% of contacts in the home likely essential. More sensitivity analysis to timing of tracing will be undertaken, but the scope for long delays is limited.
- Peak numbers of contacts needing to be traced could be between 70k and 200k per day for scenarios which successfully keep deaths at below 100/day, and higher for other scenarios. Automated solutions will likely be essential. App based contact tracing may at most capture 50% of the contacts needed – other systems for contact tracing will be essential.
- The most successful policy not requiring isolation outside the home or quarantine of contacts of contacts combines case isolation, household quarantine, isolation of 80% of contacts and reactive school closure.
- For R_0=3, this policy might restrict total deaths from June to December (inclusive) to between 8,000 and 30,000 if schools re-opened in June, and to half that if schools remained closed until September.
- Keeping schools closed until September always reduces total deaths for policies which "just" achieve sustained control of transmission. It also reduces peak and total numbers of contacts needing to be traced.
- Reactive school closure can enhance suppression, likely needed if case/contact isolation occurs in the home.
- Isolation of at least cases outside the home can substantially improve policy effectiveness.
- The three alternative transmission scenarios explored in addition to the default scenario are all generally more difficult to control – due to a higher proportion of either presymptomatic or asymptomatic transmission, or because school closure (complete or reactive) has a lower effect. However, the "MoreSocial" scenario would be easier to control than the default if it did not also include the "PreSymp" assumptions.
- We will continue to explore other policy combinations, notably geographically localised intensification of social distancing in response to epidemiological triggers, periodic social distancing (e.g. only opening leisure venues at weekends), and partial re-opening of schools (e.g. primary schools only).

Results

Figures 1 & 2 show illustrative dynamics for the policy options explored, while Tables 1-4 show predicted deaths and contacts traced for policies involving schools reopening in June versus September.

Figure 1: Daily deaths through time for policies examined, default scenario



- Lockdown continued
- School closure, case isolation, HQ, reduced social distancing
- School closure, case isolation, HQ, CT (90% symp cases, 0.5 day delay)
- School closure, case isolation, HQ, CT (90% symp cases, 0.5 day delay) and contacts of contacts (1 day delay)
- School closure, case isolation, HQ
- School closure, case isolation, HQ, reduced social distancing, CT (90% symp cases, 0.5 day delay) and contacts of contacts (1 day delay)
- School closure, case isolation, CT (90% symp cases, 0.5 day delay)
- School closure, case isolation, CT (90% symp cases, 0.5 day delay) and contacts of contacts (1 day delay)
- School closure, case isolation
- School closure, case isolation, HQ, CT (90% symp cases, 0.5 day delay) and contacts of contacts (1 day delay), isolation outside the home
- Case isolation, HQ, reduced social distancing, CT (90% symp cases, 0.5 day delay) and contacts of contacts (1 day delay), isolation outside the home
- Case isolation, HQ, reduced social distancing, CT (90% symp cases, 0.5 day delay) and contacts of contacts (1 day delay), isolation outside the home
- Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay) , isolation outside the home
- Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay) and 80% contacts of contacts (2 day delay), isolation outside the home
- Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay) and 80% contacts of contacts (2 day delay)
- Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay)
- Reactive 2 week school closure, Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay) and 80% contacts of contacts (2 day delay)
- Reactive 2 week school closure, Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay)
- Reactive 2 week school closure, Case isolation, HQ, reduced social distancing, CT (80% symp cases, 1 day delay), isolation outside the home
- Reactive 2 week school closure, Case isolation, HQ, reduced social distancing
- Reactive 2 week school closure, Case isolation, HQ, reduced social distancing, app CT (90% of smartphone users, 80% compliance, 1 day delay)
- Reactive 2 week school closure, Case isolation, HQ, reduced social distancing, app coverage CT (80% symp cases, 1 day delay) and 80% contacts of contacts (2 day delay)
- Case isolation, HQ, reduced social distancing, app coverage CT (80% symp cases, 1 day delay) and 80% contacts of contacts (2 day delay)

Figure 2: Daily deaths through time for policies which keep daily cases <100, default scenario

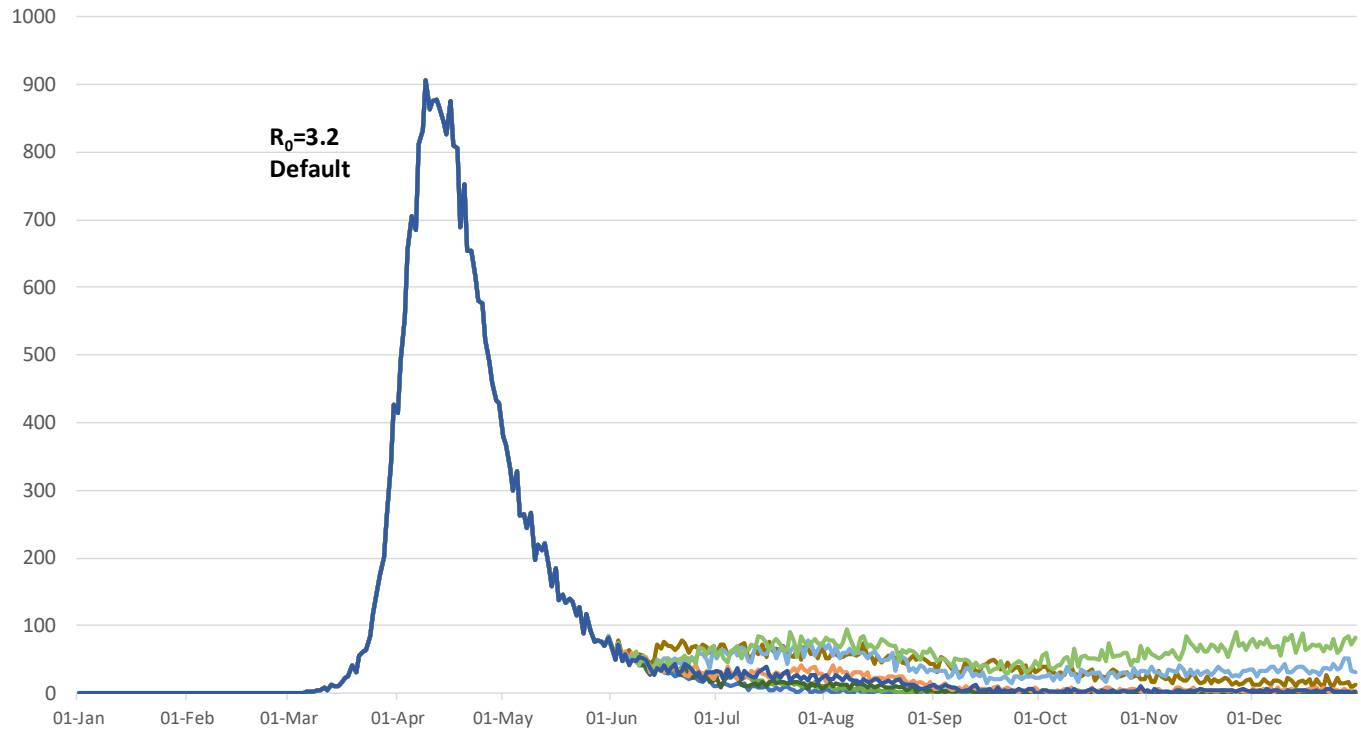


Table 1: Deaths - maximum daily and total from June-December for different policy options (schools reopening June), R_0=3. Empty cells imply a policy is not implemented. Symptomatic case isolation of 90% of cases is assumed in all scenarios.

							Max daily deaths				Total deaths June-Dec			
School closure	Social distancing	Household quarantine	Contact tracing coverage	Contact tracing delay	Contacts of contacts	Isolation outside the home	Default	PreSymp	MoreSocial	LowKids	Default	PreSymp	MoreSocial	LowKids
Yes	Full	75%					60	106	40	99	925	2501	556	2045
Yes	Reduced	75%					208	423	165	288	21987	57105	14413	38539
Yes		75%	90%	0.5			1017	794	1268	1367	128857	109823	151716	153580
Yes		75%	90%	0.5	Yes		511	451	751	599	62682	56834	87447	63741
Yes		75%		0.5			5867	6786	11674	5305	363828	345278	475175	291190
Yes	Reduced	75%	90%	0.5	Yes		52	107	41	102	1262	2986	933	3313
Yes			90%	0.5			1681	1335	1637	1908	193686	166520	196162	191364
Yes			90%	0.5	Yes		962	890	1184	961	104518	99515	125632	87636
Yes							9703	10686	16648	7422	459153	431400	559583	343081
Yes		75%	90%	0.5	Yes	Yes	59	129	61	177	4293	6045	8136	18048
	Reduced	75%	90%	0.5	Yes	Yes	81	147	98	308	9945	13164	11056	23632
	Reduced	75%	90%	0.5	Yes	Yes	58	104	40	106	1306	3619	779	6211
	Reduced	75%	80%	1		Yes	53	179	34	403	5069	19935	1908	45503
	Reduced	75%	80%	1	Yes	Yes	57	109	37	135	2163	6673	1192	8968
	Reduced	75%	80%	1	Yes		214	635	182	503	22979	42585	17475	31803
	Reduced	75%	80%	1			647	1004	425	1038	56362	80094	39057	85201
Reactive	Reduced	75%	80%	1	Yes		55	155	51	172	5617	14071	5912	16153
Reactive	Reduced	75%	80%	1			61	162	73	212	7706	20387	8728	29285
Reactive	Reduced	75%	80%	1		Yes	53	111	34	109	1871	5222	1178	13423
Reactive	Reduced	75%					148	555	350	388	18703	75262	40614	56850
Reactive	Reduced	75%	72% of SPU	1			83	236	150	275	11069	33233	17309	39318
Reactive	Reduced	75%	72% of SPU	1	Yes		79	233	124	238	9880	27121	14566	29851
	Reduced	75%	72% of SPU	1	Yes		1452	3496	1273	2198	131032	131576	119715	97449

Table 2: Contacts - maximum daily and total from June-December for different policy options (schools reopening June), R_0=3

							Max daily contacts (thousands)				Total contacts June-Dec (thousands)			
School closure	Social distancing	Household quarantine	Contact tracing coverage	Contact tracing delay	Contacts of contacts	Isolation outside the home	Default	PreSymp	MoreSocial	LowKids	Default	PreSymp	MoreSocial	LowKids
Yes	Full	75%					0	0	0	0	0	0	0	0
Yes	Reduced	75%					0	0	0	0	0	0	0	0
Yes		75%	90%	0.5			963	867	1420	1055	137303	131260	203172	128355
Yes		75%	90%	0.5	Yes		776	663	1282	1039	111889	96065	181278	130528
Yes		75%		0.5			0	0	0	0	0	0	0	0
Yes	Reduced	75%	90%	0.5	Yes		74	196	84	164	1908	4565	2134	6396
Yes			90%	0.5			1384	1326	1817	1349	182334	183660	236080	146650
Yes			90%	0.5	Yes		1356	1261	1796	1456	181074	171170	240458	177229
Yes							0	0	0	0	0	0	0	0
Yes		75%	90%	0.5	Yes	Yes	78	218	129	297	6076	8537	19279	33696
	Reduced	75%	90%	0.5	Yes	Yes	143	279	203	726	19603	26755	29720	55305
	Reduced	75%	90%	0.5	Yes	Yes	53	157	67	276	2276	7868	1815	19527
	Reduced	75%	80%	1		Yes	112	407	64	613	10472	46849	5749	72686
	Reduced	75%	80%	1	Yes	Yes	62	225	69	427	4670	16680	3538	28599
	Reduced	75%	80%	1	Yes		519	1172	584	1203	66044	96713	70913	98982
	Reduced	75%	80%	1			884	1300	940	1240	100653	129685	110607	113151
Reactive	Reduced	75%	80%	1	Yes		121	334	165	413	14415	35030	23299	49841
Reactive	Reduced	75%	80%	1			105	304	206	312	15458	41797	28781	48248
Reactive	Reduced	75%	80%	1		Yes	50	158	64	153	2566	9313	2951	21507
Reactive	Reduced	75%					0	0	0	0	0	0	0	0
Reactive	Reduced	75%	72% of SPU	1			54	161	143	164	8271	24779	20170	25396
Reactive	Reduced	75%	72% of SPU	1	Yes		56	178	137	222	9144	24822	20259	32917
	Reduced	75%	72% of SPU	1	Yes		899	1231	1044	1108	87629	53624	102475	66922

Table 3: Deaths - maximum daily and total from June-December for different policy options (schools reopening September), R_0=3

							Max daily deaths				Total deaths June-Dec			
School closure	Social distancing	Household quarantine	Contact tracing coverage	Contact tracing delay	Contacts of contacts	Isolation outside the home	Default	PreSymp	MoreSocial	LowKids	Default	PreSymp	MoreSocial	LowKids
Yes	Full	75%					60	106	40	99	925	2501	556	2045
Yes	Reduced	75%					208	423	165	288	21987	57105	14413	38539
Yes		75%	90%	0.5			1017	794	1268	1367	128857	109823	151716	153580
Yes		75%	90%	0.5	Yes		511	451	751	599	62682	56834	87447	63741
Yes		75%		0.5			5867	6786	11674	5305	363828	345278	475175	291190
Yes	Reduced	75%	90%	0.5	Yes		52	107	41	102	1262	2986	933	3313
Yes			90%	0.5			1681	1335	1637	1908	193686	166520	196162	191364
Yes			90%	0.5	Yes		962	890	1184	961	104518	99515	125632	87636
Yes							9703	10686	16648	7422	459153	431400	559583	343081
Yes		75%	90%	0.5	Yes	Yes	59	129	61	177	4293	6045	8136	18048
	Reduced	75%	90%	0.5	Yes	Yes	59	129	61	192	5637	7742	8981	21527
	Reduced	75%	90%	0.5	Yes	Yes	56	110	37	103	901	1867	576	2175
	Reduced	75%	80%	1		Yes	54	108	39	357	1085	2924	656	12993
	Reduced	75%	80%	1	Yes	Yes	56	114	40	108	950	2136	640	2901
	Reduced	75%	80%	1	Yes		101	521	84	395	3884	22768	3055	19970
	Reduced	75%	80%	1			275	856	255	1053	7877	47372	7457	58266
Reactive	Reduced	75%	80%	1	Yes		54	104	37	106	1880	6770	1686	8691
Reactive	Reduced	75%	80%	1			54	132	39	202	2309	10116	2480	15298
Reactive	Reduced	75%	80%	1		Yes	54	108	39	101	1060	2364	656	4440
Reactive	Reduced	75%					121	571	298	420	8500	58349	17511	36927
Reactive	Reduced	75%	72% of SPU	1			58	224	119	282	4030	19982	5956	22403
Reactive	Reduced	75%	72% of SPU	1	Yes		57	195	99	228	3313	16615	4944	16792
	Reduced	75%	72% of SPU	1	Yes		2345	3099	2123	1929	101190	141023	90719	103268

Table 4: Contacts - maximum daily and total from June-December for different policy options (schools reopening September), R_0=3

							Max daily contacts (thousands)				Total contacts June-Dec (thousands)			
School closure	Social distancing	Household quarantine	Contact tracing coverage	Contact tracing delay	Contacts of contacts	Isolation outside the home	Default	PreSymp	MoreSocial	LowKids	Default	PreSymp	MoreSocial	LowKids
Yes	Full	75%					0	0	0	0	0	0	0	0
Yes	Reduced	75%					0	0	0	0	0	0	0	0
Yes		75%	90%	0.5			963	867	1420	1055	137303	131260	203172	128355
Yes		75%	90%	0.5	Yes		776	663	1282	1039	111889	96065	181278	130528
Yes		75%		0.5			0	0	0	0	0	0	0	0
Yes	Reduced	75%	90%	0.5	Yes		74	196	84	164	1908	4565	2134	6396
Yes			90%	0.5			1384	1326	1817	1349	182334	183660	236080	146650
Yes			90%	0.5	Yes		1356	1261	1796	1456	181074	171170	240458	177229
Yes							0	0	0	0	0	0	0	0
Yes		75%	90%	0.5	Yes	Yes	78	218	129	297	6076	8537	19279	33696
	Reduced	75%	90%	0.5	Yes	Yes	78	218	131	298	10110	13560	23986	48722
	Reduced	75%	90%	0.5	Yes	Yes	51	154	61	119	788	1876	830	3459
	Reduced	75%	80%	1		Yes	46	150	66	626	913	4798	995	27591
	Reduced	75%	80%	1	Yes	Yes	58	171	72	125	1021	2506	1038	6447
	Reduced	75%	80%	1	Yes		336	1011	382	974	12547	59670	14440	67649
	Reduced	75%	80%	1			627	1132	820	1111	21076	81127	29925	81076
Reactive	Reduced	75%	80%	1	Yes		75	210	81	320	3904	17016	5644	27076
Reactive	Reduced	75%	80%	1			61	247	131	303	3980	21746	8301	27663
Reactive	Reduced	75%	80%	1		Yes	46	150	66	90	847	2612	995	6650
Reactive	Reduced	75%					0	0	0	0	0	0	0	0
Reactive	Reduced	75%	72% of SPU	1			38	148	132	163	2877	15811	7925	15890
Reactive	Reduced	75%	72% of SPU	1	Yes		38	152	129	218	2987	15556	7297	18942
	Reduced	75%	72% of SPU	1	Yes		953	1088	1011	938	56751	59608	61342	64390