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Modellering COVID-19





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Inhoud

1. Doel van modelleren tijdens COVID-19-epidemie
2. Voorbeelden data-analyse
3. Transmissiemodel
4. Modelleren van contacten en maatregelen



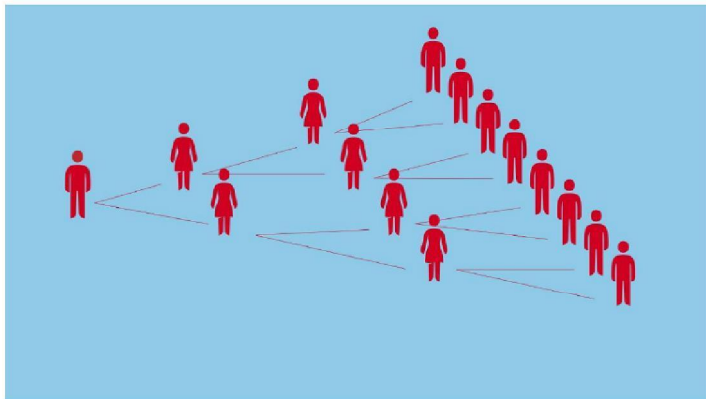
Doel van het modelleren

- Begrijpen virusverspreiding (in Nederland)
 - epidemiologische karakteristieken
 - > incubatieperiode (tijd van infectie tot symptomen)
 - > serial interval (tijd tussen opeenvolgende infecties)
 - > reproductiegetal
 - > kansen/tijdsintervallen (ziekenhuis/IC/sterfte)
- Inschatten effectiviteit van maatregelen
 - retrospectief: verloop reproductiegetal
 - prospectief: effect van veranderde contacten op reproductiegetal
 - prospectief: tijdsverloop van IC-/ziekenhuisopnames

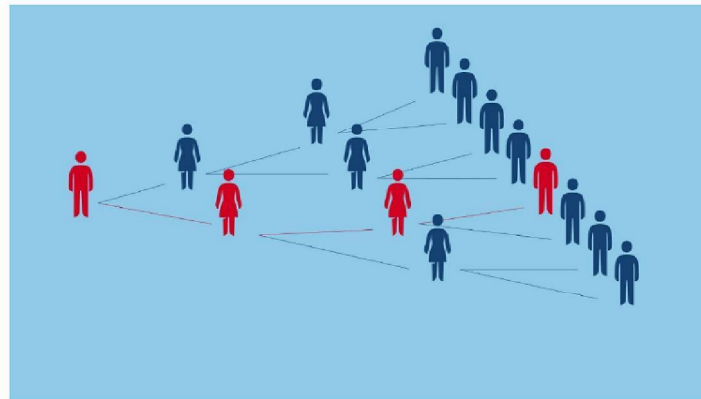


Reproductiegetal

- Gemiddeld aan nieuwe besmettingen veroorzaakt door elk geïnfecteerd persoon
 - als $R > 1$, dan toename infecties
 - als $R < 1$, dan afname infecties



$R_0 = 2$



$R_0 = 1$



Incubatieperiode: Chinese data

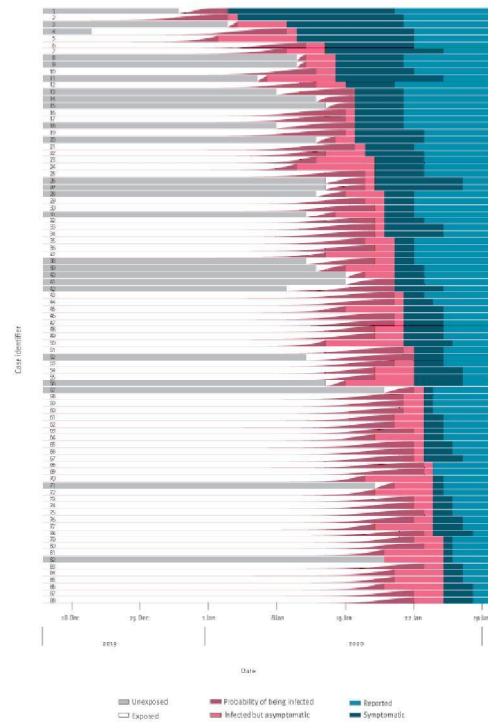
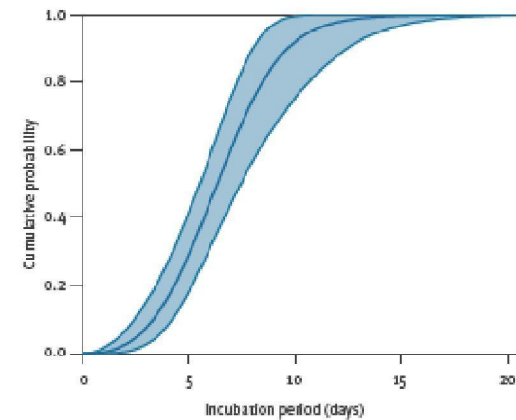


FIGURE 2

The cumulative density function of the estimated Weibull incubation period distribution for travellers infected with the 2019 novel coronavirus (2019-nCoV) in Wuhan, China, data 20–28 January 2020

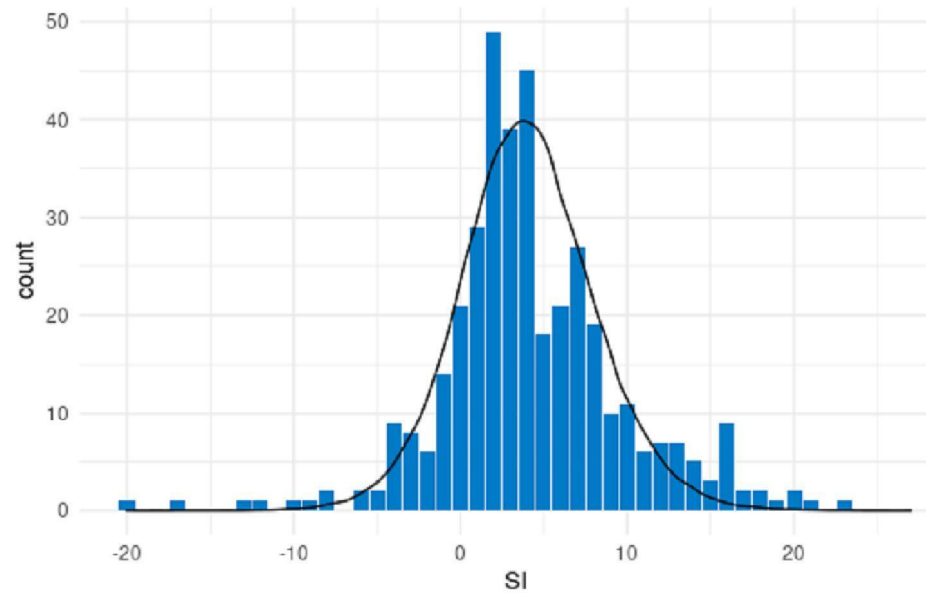


Posterior median of mean is indicated by the dark blue line and the 95% credible interval by the light blue area.



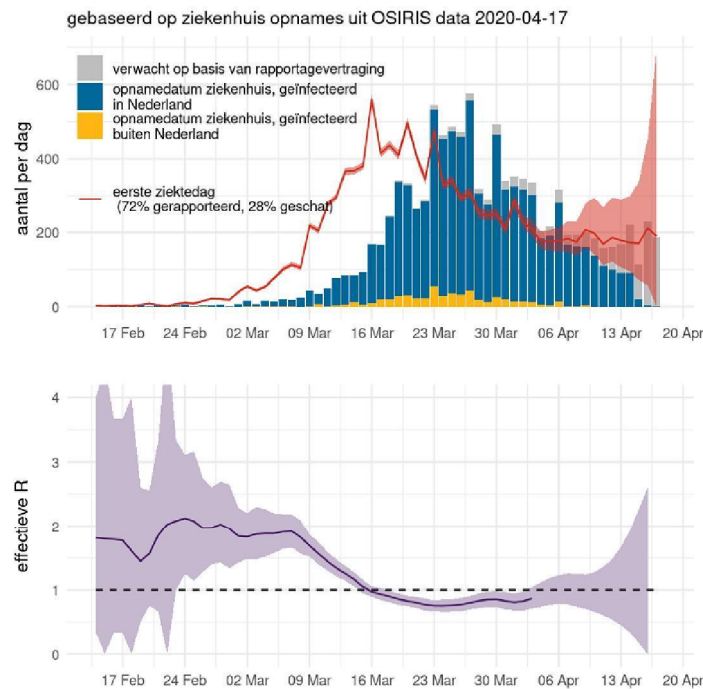
Serial interval

- tijd tussen aanvang symptomen van patient en degene door wie hij/zij is geïnfecteerd (infector)





Effect van maatregelen retrospectief

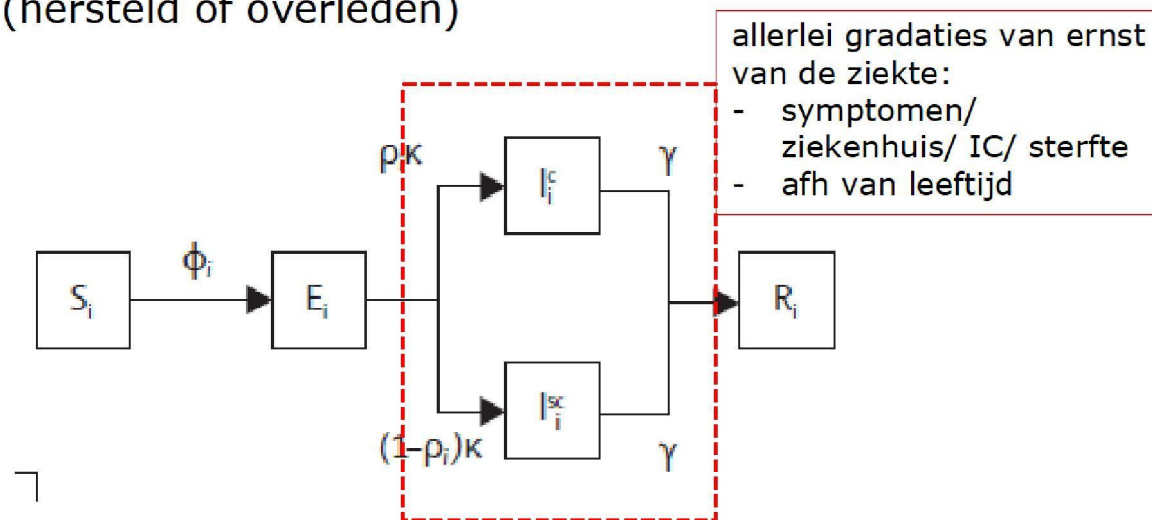


- OSIRIS
- **Blauw**: meldingen ziekenhuisopname naar opnamedatum
- **Grijs**: verwachte meldingen (correctie voor rapportagevertraging)
- **Rood**: eerste ziektedag van opgenomen patiënten
- Data meer recent dan 3 April zijn onzeker.
- **Paars**: reproductiegetal, aantal secundaire besmettingen per geval
 - reflecteert de toename en afname van de rode epicurve
 - berekend volgens Wallinga & Lipsitch Proc R Soc B 2007
- Schattingen meer recent dan 3 April zijn onzeker.



Effect van maatregelen prospectief

- Transmissiemodel: SEIR
 - susceptible (vatbaar)
 - exposed (geïnfecteerd maar nog niet besmettelijk)
 - infected and infectious (besmettelijk)
 - removed (hersteld of overleden)

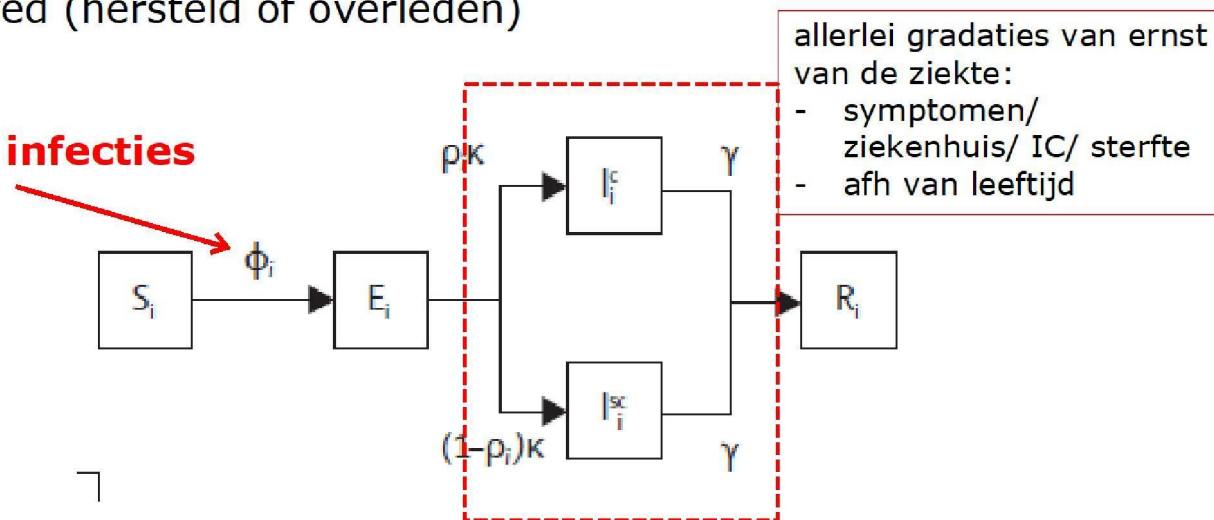




Effect van maatregelen prospectief

- Transmissiemodel: SEIR
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nieuwe infecties



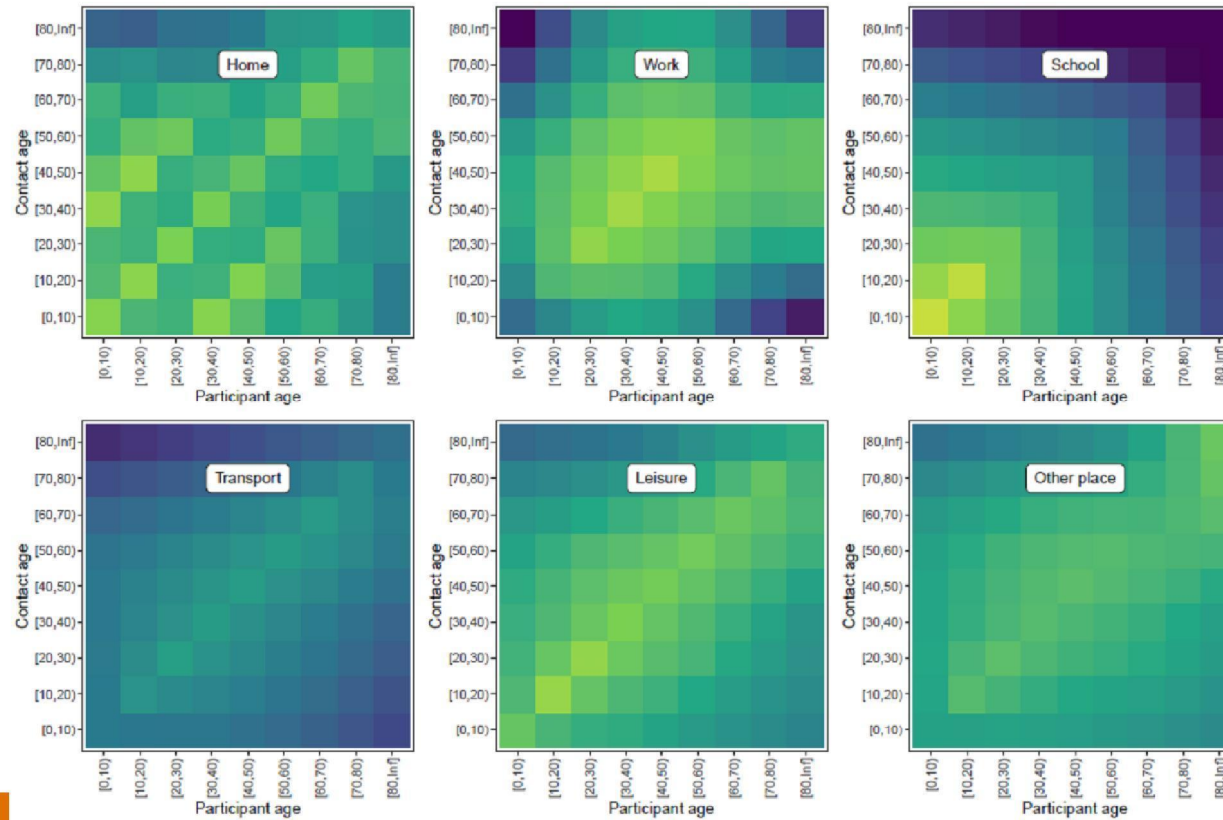


Nieuwe infecties door contacten

- PIENTER-studie (laatste: 2017)
 - nationale dwarsdoorsnede van bevolking
 - primair: bepalen immuniteit tegen RVP-infectieziekten
 - › RVP = rijksvaccinatieprogramma
 - vragenlijst voor alle deelnemers
 - › vraag over contacten ('gisteren')
 - dagboekjes voor deel van de deelnemers
 - › alle contacten noteren
 - › leeftijd van gecontacteerden
 - › setting van het contact



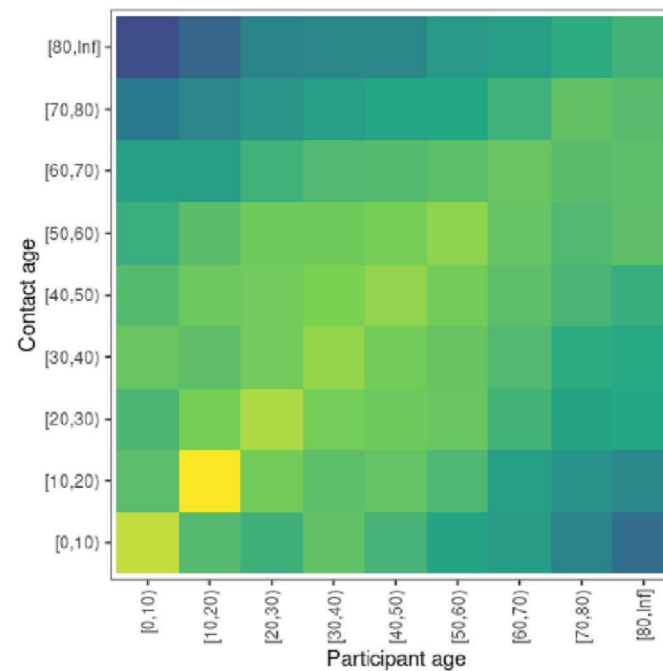
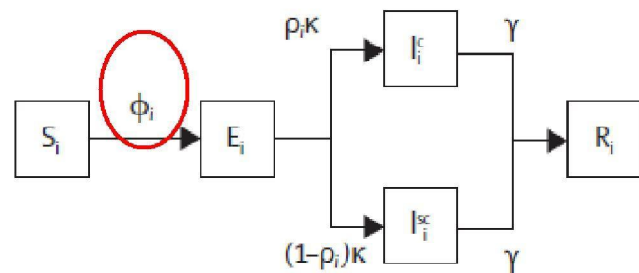
Nieuwe infecties door contacten





Nieuwe infecties door contacten

- Soorten contacten opgeteld: totaal tussen elke leeftijdsgroep
- Direct ingevoerd in SEIR-model
 - **besmettingskans** voor persoon =
 - > contactrate met anderen
 - > kans dat de ander besmet is
 - prevalentie
 - > infectiviteit
 - > vatbaarheid





Effect van maatregelen

- Verandering van gedrag in relatie tot ziekte
 - isolatie
 - huishoudquarantaine
 - contacttraceren
- Verandering in contactfrequenties
 - scholen dicht
 - thuiswerk
 - restaurants/sportclubs, etc
- Verandering van overdrachtskans bij contacten
 - afstand houden
 - handen wassen/hygiëne



Werkwijze: effect maatregelen inschatten

- Per maatregel inschatten
 - waarop grijpt de maatregel in?
 - > contacten: zowel geïnfecteerde als vatbare
 - > infectiviteit: alleen geïnfecteerde
 - mechanistisch mogelijk wel contact
 - hoe groot is het effect bij uitvoeren?
 - wat is de ingeschatte compliance
- Verschillen tussen leeftijdsklassen mogelijk



Voorbeeld (paar regels uit enorme lijst)

Measure	Target group	Effect type	Age	Effect	Compliance	Motivation
Case finding, active monitoring, and isolation	Cases	Infectiousness	All	40%	50%	50% asymptomatic (compliance). 50% presymptomatic + two days delay after symptom onset (effect)
Contact tracing and isolation; quarantine	Cases, contacts	Infectiousness	All	75%	40%	50% asymptomatic & 80% traced (compliance). Two days off presymptomatic transmission & no symptomatic transmission (effect)
Contact tracing and isolation; active monitoring	Cases, contacts	Infectiousness	All	60%	40%	50% asymptomatic & 80% traced (compliance). reduced transmission before symptoms (effect)
Self-quarantine when at event or location of a known case	General	All contacts Corp hh	All	80% *1.5	20%	
Keeping 2 m distance	High-risk groups (60+ and underlying illness)	All contacts except hh	60-100	80%	50%	People want to, but it's not practical in daily life (compliance)
Limit social activities		Leisure	All	100%	50%	People are willing to some degree (compliance)
Awareness campaign	Spreaders (40-70 year olds)	All	40-70	50%	20%	Skepticism, not practical (compliance)
No visits to high-risk people	General	All Maybe not work (home care?)	>60 contact matrix, all for reduced burden? (difficult to compensate)	80%	50%	People do want but not always practical (compliance)
No handshake	General	Work, leisure	>20	20%	100%	Small part of all contacts (effect)



Voorbeeld (paar regels uit enorme lijst)

Measure	Target group	Effect type	Age	Effect	Compliance	Motivation
closing Church	General	Leasure, transport	All	5%	100%	Small part of the population (effect)
closing restaurants and bars	General	Work, leasure, transport	All	25%	90%	Some fraction of all contacts (effect)
Closing sport clubs, fitness gym	General	Leasure, transport	All	10%	90%	Small fraction of all contacts
Shopping only when essential	General	Leasure, transport, Work	>20	10%	80%	Small fraction of all contacts
Closing daycare	General	Work/school?, hh (compensatory)	<10 20-50	40% (<10) 20% (20-50) *1.5 (hh)	100%	Only age<4 (effect <10) Work: parents staying home
Closing primary schools	General	School, hh/leasure comp.	0-10 10-20 20-60	60% 20% 25% *1.5 (hh/leasure)	100%	Only age 5-12 Work: parents staying home & staff
Closing secondary schools	General	School, hh/leasure comp.	10-20 20-60	50% 15% *1.5	100%	Only age 5-12 Work: parents staying home& staff
Closing colleges and universities	General	School, work, hh/leasure comp	10-20 20-30 30-60	10% 20% 5%	100%	Students (10-30) assuming 50% is student from 18-24. Work is staff, not parents
Work from home	General	Work, hh comp	20-60	100% hh/leasure *1.5	30%	For many jobs not possible (compliance)



Werkwijze: effect maatregelen inschatten

- Onafhankelijk door drie personen
- Dan consensuslijst

- Effect van elke maatregel individueel => daling in reproductiegetal



Effect van individuele maatregelen

MeasureID	Measure	Target group	Effect type	Age	Effect	Compliance	Effect on reproduction number				Motivation S1 norm with mean 5d, sd 3d IP gamma with mean 5d, sd 2.5d (shape 4) G1 norm with mean 5d, sd 1d Inf interval around SO norm with mean 0, sd 2
							primary	less work	more home /leisure	total	
1	Case finding and isolation	Cases, contacts	Infectiousness	All	16%	100%	- 16%			- 16%	16% of infections take place after 2 days since SO
2	Contact tracing and quarantine	Cases, contacts	Infectiousness	All	56%	90%	- 51%			- 51%	Effect consists of 75% to find contact, 75% effective in preventing transmission (start quarantine and stop transmission 2d after SO of case)
3	Contact tracing and active monitoring	Cases, contacts	Infectiousness	All	33%	100%	- 33%			- 33%	Effect consists of 75% to find contact, 44% effective in preventing transmission (start monitoring 2d after SO of case, stop transmission at SO of contact)
4	Self-quarantine when at event or location of a known case	General	Infectiousness Comp HH	All	27% HH*1.2	50%	- 13%		+ 3%	- 10%	Effect consists of 50% to inform contacts, 53% effective in preventing transmission (start self-quarantine 4d after SO of case)
5	Check temperature, self-isolation when fever	General	Infectiousness Comp HH	All	25% HH*1.2	50%	- 13%		+ 3.7%	- 9.3%	50% infections after SO prevented, reduced by 50% (due to onward transmission via household members)
6	Check temperature, self-isolation when fever, household members in quarantine	General	Infectiousness Comp HH	All	50% HH*1.2	50%	- 25%		+ 3%	- 22%	50% infections after SO prevented, no onward transmission via household members
7	Self-isolation when having mild respiratory symptoms	General	Infectiousness Comp HH	All	35% HH*1.2	50%	- 17%		+ 3%	- 14%	69% infections after 1d before SO prevented, reduced by 50% (due to onward transmission via household members)



Werkwijze: effect maatregelen inschatten

- Onafhankelijk door drie personen
- Dan consensuslijst

- Effect van elke maatregel individueel => daling in reproductiegetal

- Vervolgens: pakketten van maatregelen samenstellen
 - op basis van overleg met responsteam/OMT
- Alle effecten op alle typen contacten/infectiviteit combineren
- Uiteindelijk:
 - reductie per contacttype/infectiviteit per leeftijd
 - nieuwe contactmatrices berekenen
 - simuleren

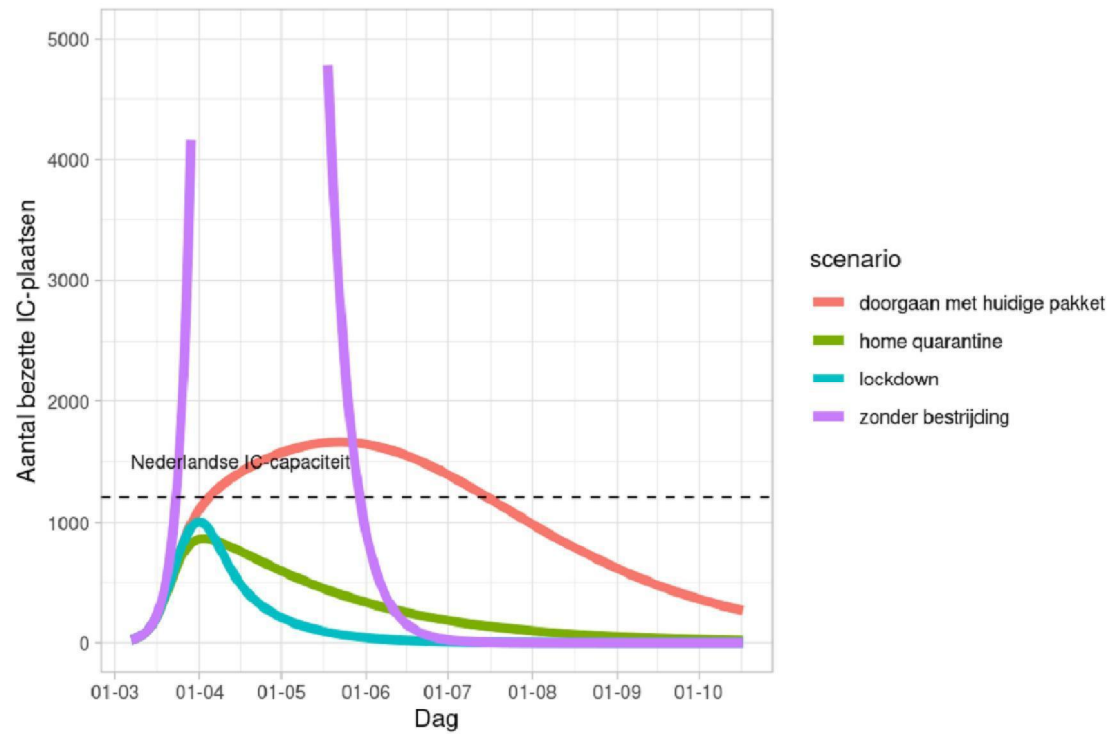


Pakketten aan maatregelen

D1	Work from home + limit social (-50%) + self-isolation with mild symptoms (see 7 without comp)	General	Work Transport Leisure Comp hh Infectiousness	20-70 All All 20-70 All	100% 100% 50% hh * 1.5 17%	40% 32.5% 100%					See 30 50% of transport is for work reduced by 40%, 25% of transport is for leisure reduced by 50% 50% of leisure cancelled
D2	Work from home + limit social (-100%) + self-isolation with mild symptoms (see 7 without comp)	General	Work Transport Leisure Comp hh Infectiousness	20-70 All All 20-70 All	100% 100% 100% hh * 1.5 17%	40% 45% 100%					See 30 50% of transport is for work reduced by 40%, 25% of transport is for leisure reduced by 100% 100% of leisure cancelled
D3	Work from home + limit social (-100%) + school closure + self-isolation with mild symptoms (see 7 without comp)	General	Work Transport Leisure School Comp hh Infectiousness	20-70 All All All All All	100% 100% 100% 100% hh * 1.5 17%	40% 70% 100% 100%					See 30 50% of transport is for work reduced by 40%, 25% of transport is for leisure reduced by 100% 25% of transport is for school reduced by 100% 100% of leisure cancelled 100% of school cancelled

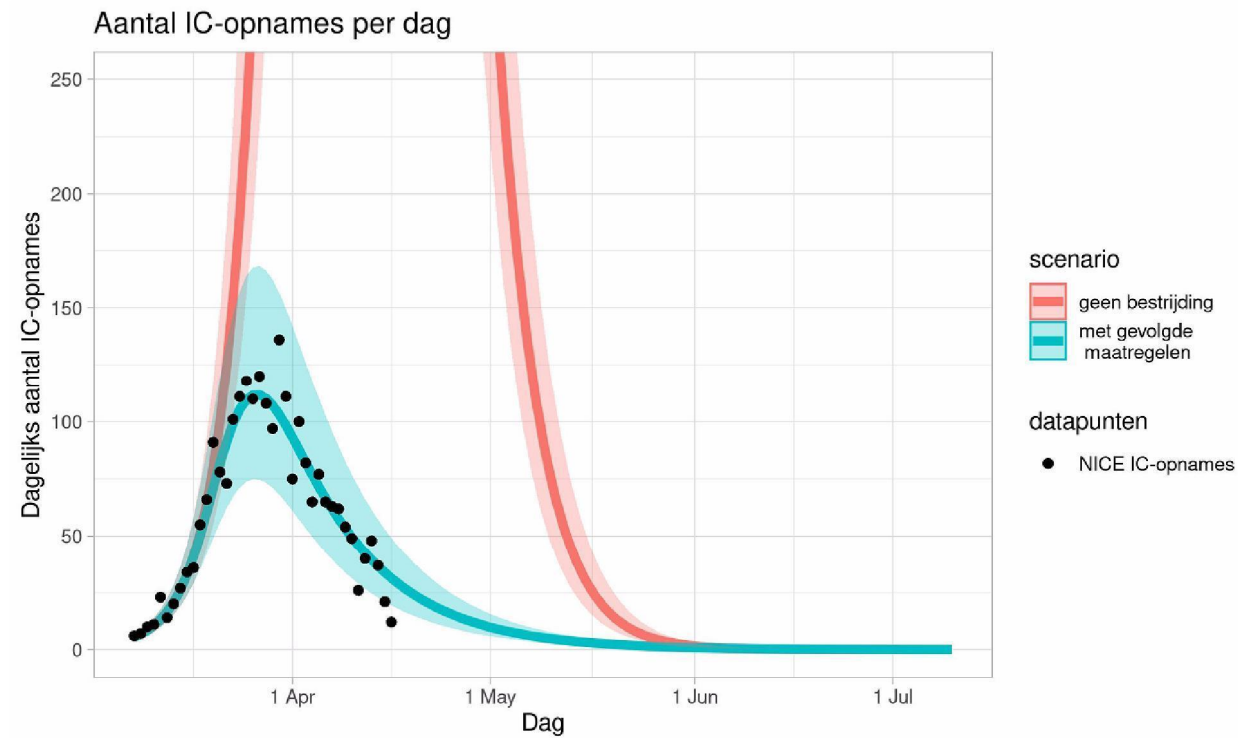


Input voor simulaties





Simulaties steeds meer geijkt op data





Bij verandering van maatregelen: terug naar effecten

