On the reliability of predictions on COVID-19 dynamics : a systematic and critical review of modeling techniques

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Abomey-Calavi, September 08th, 2020

Adapted from

On the reliability of predictions on Covid-19 dynamics: a systematic and critical review of modeling techniques

Submitted to *Infectious Disease Modelling*

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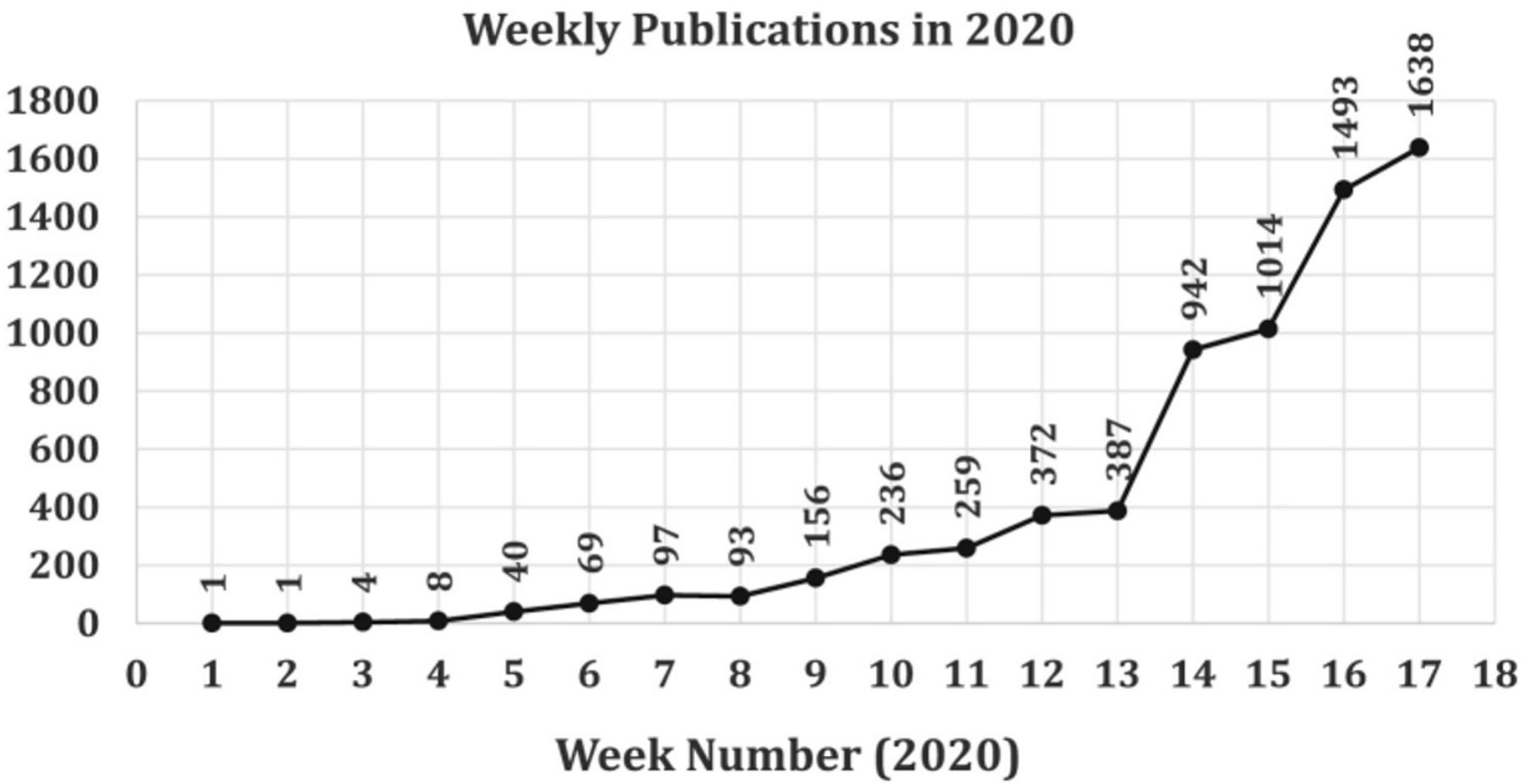
Abstract

Since the beginning of the new coronavirus 2019-nCoV disease (Covid-19) in December 2019, there has been an exponential number of studies using diverse modeling techniques to assess the dynamics of transmission of the disease, predict its future course, and determine the impacts of different control measures. The reliability and correctness of predictions of Covid-19 confirmed cases and deaths have been questioned. Here, we conducted a global systematic literature review to summarize trends in the modeling techniques used for Covid-19. We further examined the reliability and correctness of predictions by comparing predicted values and observed values for cumulative cases and deaths. From an initial 2170 peer-reviewed articles and preprints found with our defined keywords, 148 were fully analyzed. We found that most studies on the modeling of Covid-19 were

OUTLINE

Motivations

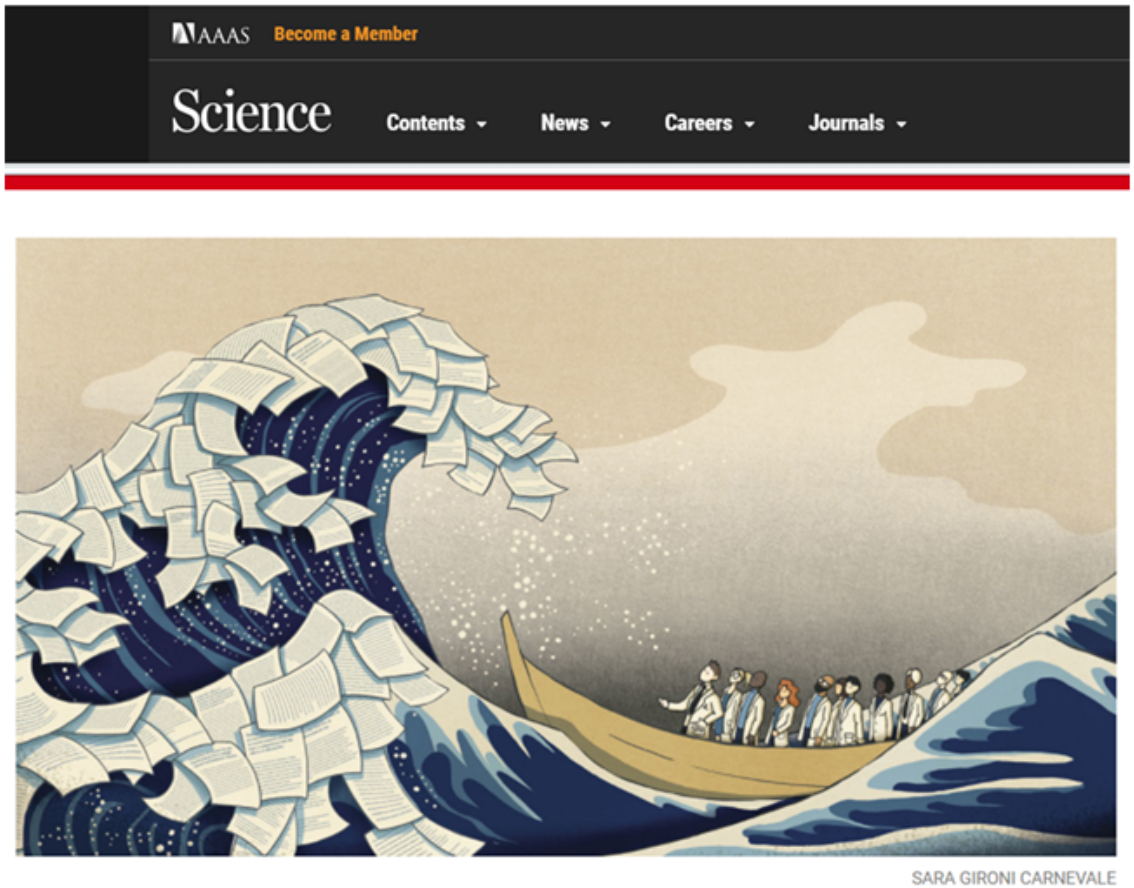
Unprecedented surge in publications related to COVID-19



Kambhampati et al. (2020).

Motivations

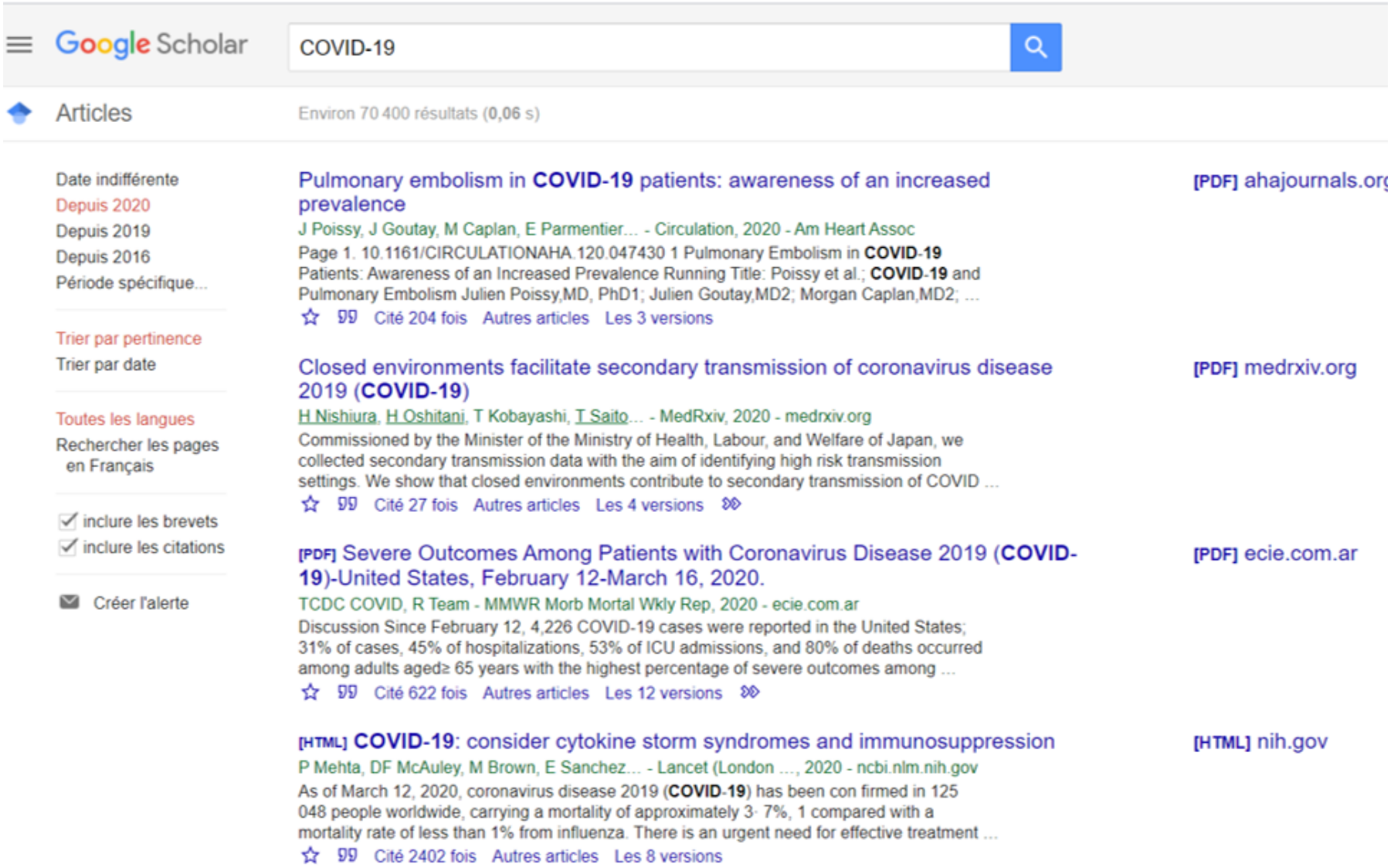
Unprecedented surge in publications related to COVID-19



Timothy Sheahan, a virologist studying COVID-19, **wishes he could keep pace with the growing torrent of new scientific papers about the disease and the novel coronavirus that causes it**. **But there are just too many—more than 4000 alone last week**. **"I'm not keeping up,"** says Sheahan, who works at the University of North Carolina, Chapel Hill. "It's impossible."

Motivations

Unprecedented surge in publications related to COVID-19



Motivations

Questioning accuracy and correctness of COVID-19 predictions'

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Why is it difficult to accurately predict the COVID-19 epidemic?

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Objectives

- Summarize trends in the modelling techniques used to predict Covid-19 cases ;
- Assess the reliability of predictions of Covid-19 cases ;
- Discuss to what extent studies accurately and correctly predict Covid-19 cases and whether some differences exist among modelling techniques.

Methods

Period
January 1st to 30 June 2020

Keywords for search

- Coronavirus,
- Covid-19,
- Corona,
- SARS viruses and
- 2019-nCoV

- Modelling,
- Prediction / Predicting
- Dynamics
- Forecasts / Forecasting

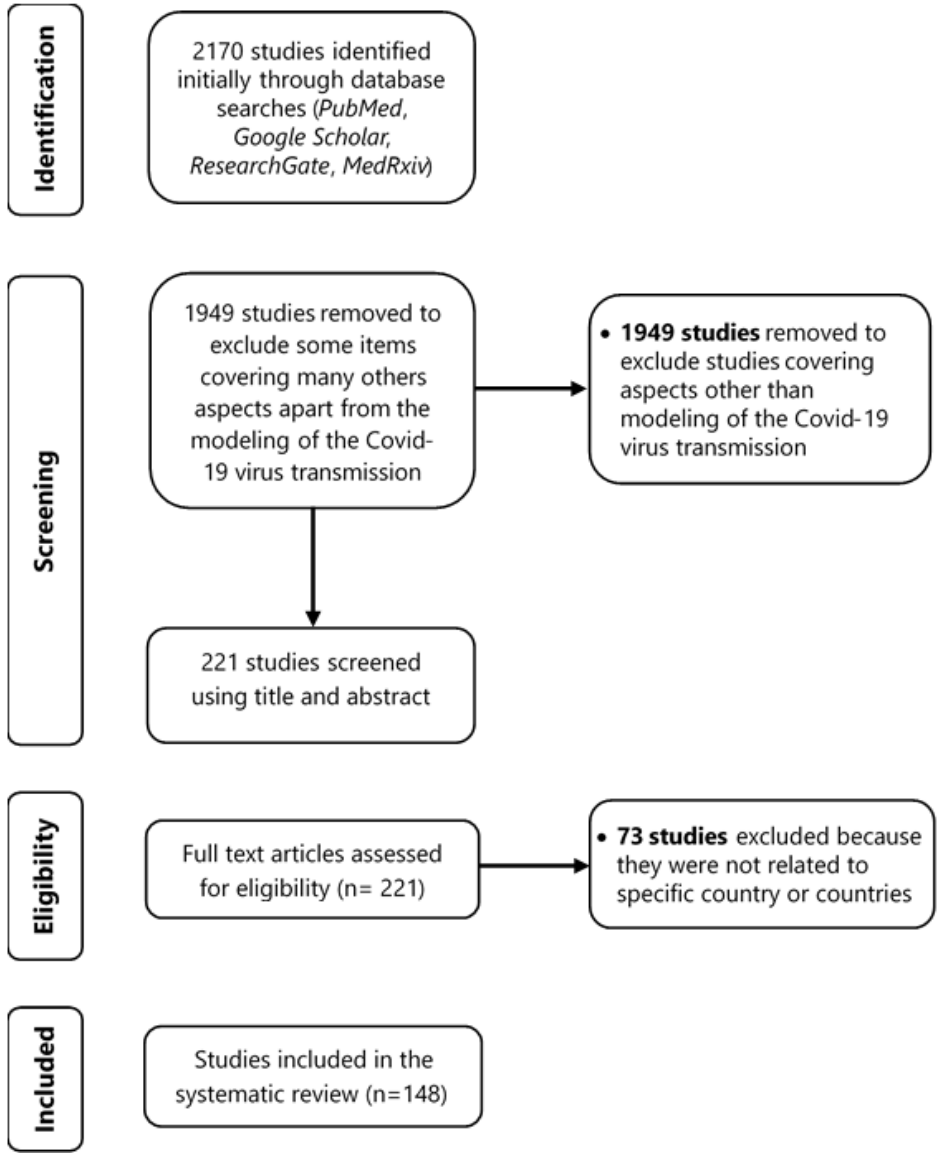

FIGURE 1 – Flow diagram (PRISMA) showing how articles were screened and selected

Literature synthesis and analysis

- Country of the study ;
- Publication status ;
- The time period covered by the data (in days) ;
- Topics addressed in the study ;
- Modeling techniques used ;
- Predicted values of the cumulative number of cases ;
- Date at which the predicted values will be observed ;
- Uncertainty parameters (95% CI or 95% CrI).

Results

Characteristics of the studies included in the review

Publication status

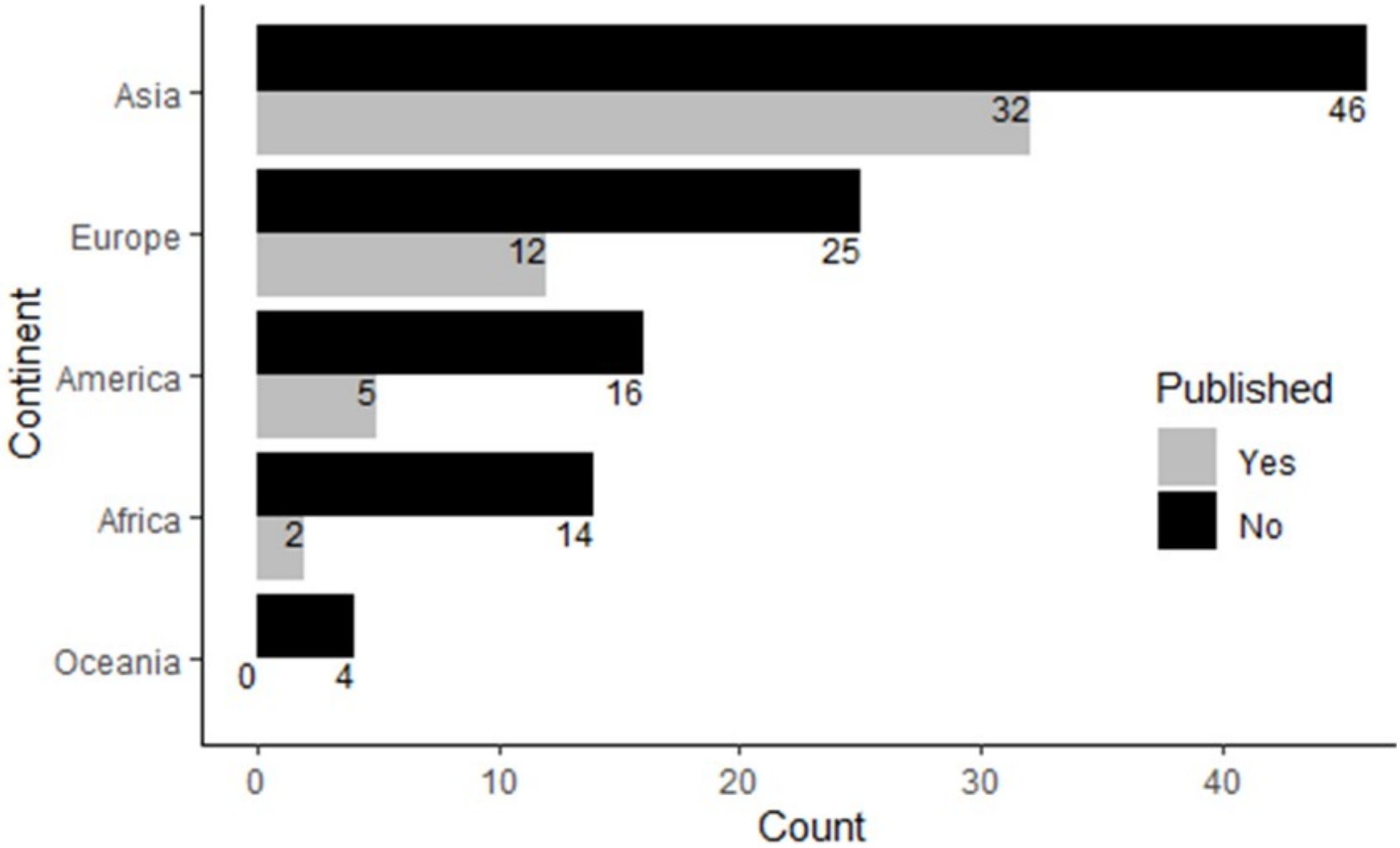

FIGURE 2 – Countries coverage (in %) across Continent

Results

Characteristics of the studies included in the review

Geographical coverage

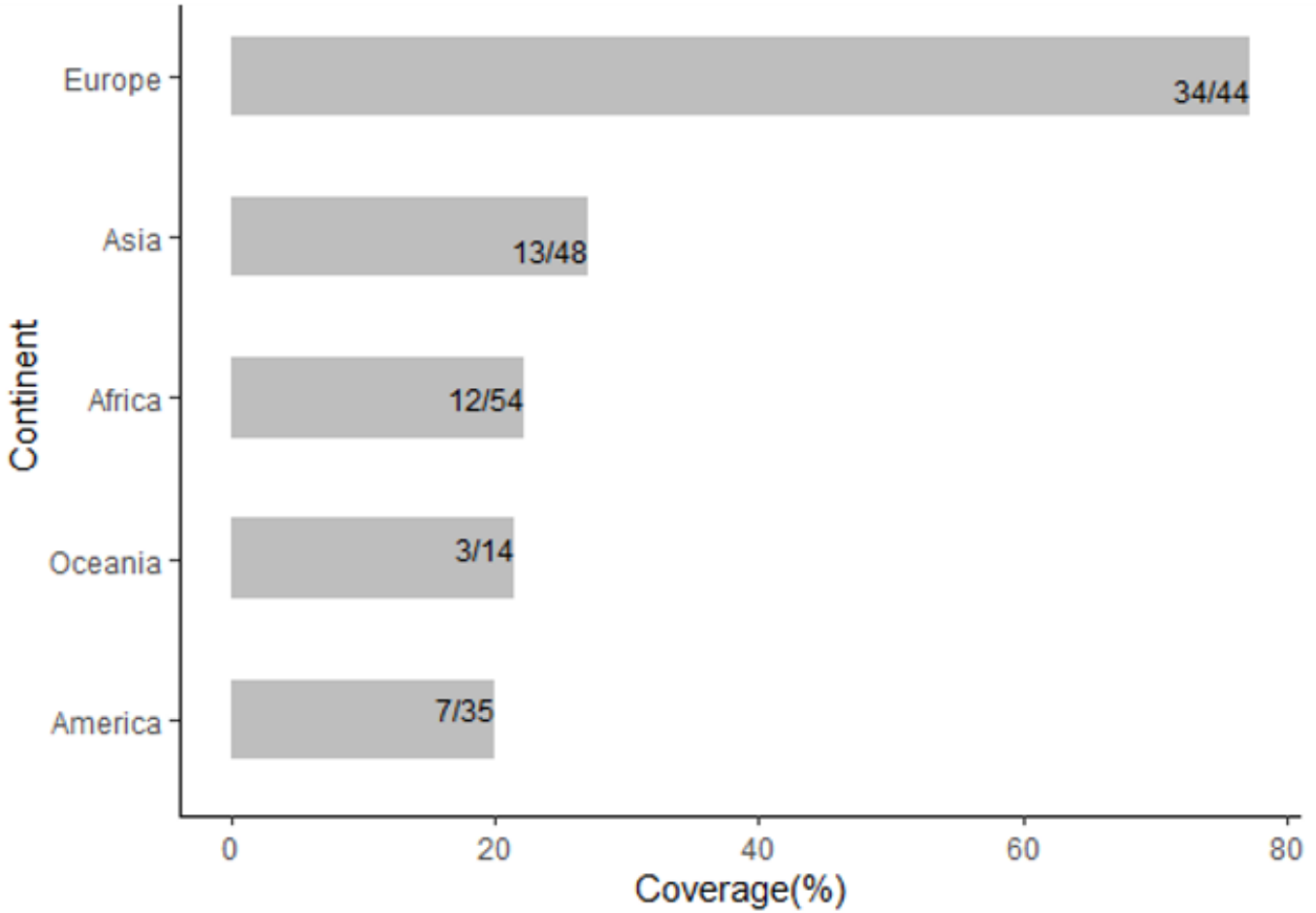

FIGURE 3 – Countries coverage (in %) across Continent

Results

Characteristics of the studies included in the review

Topics addressed by studies

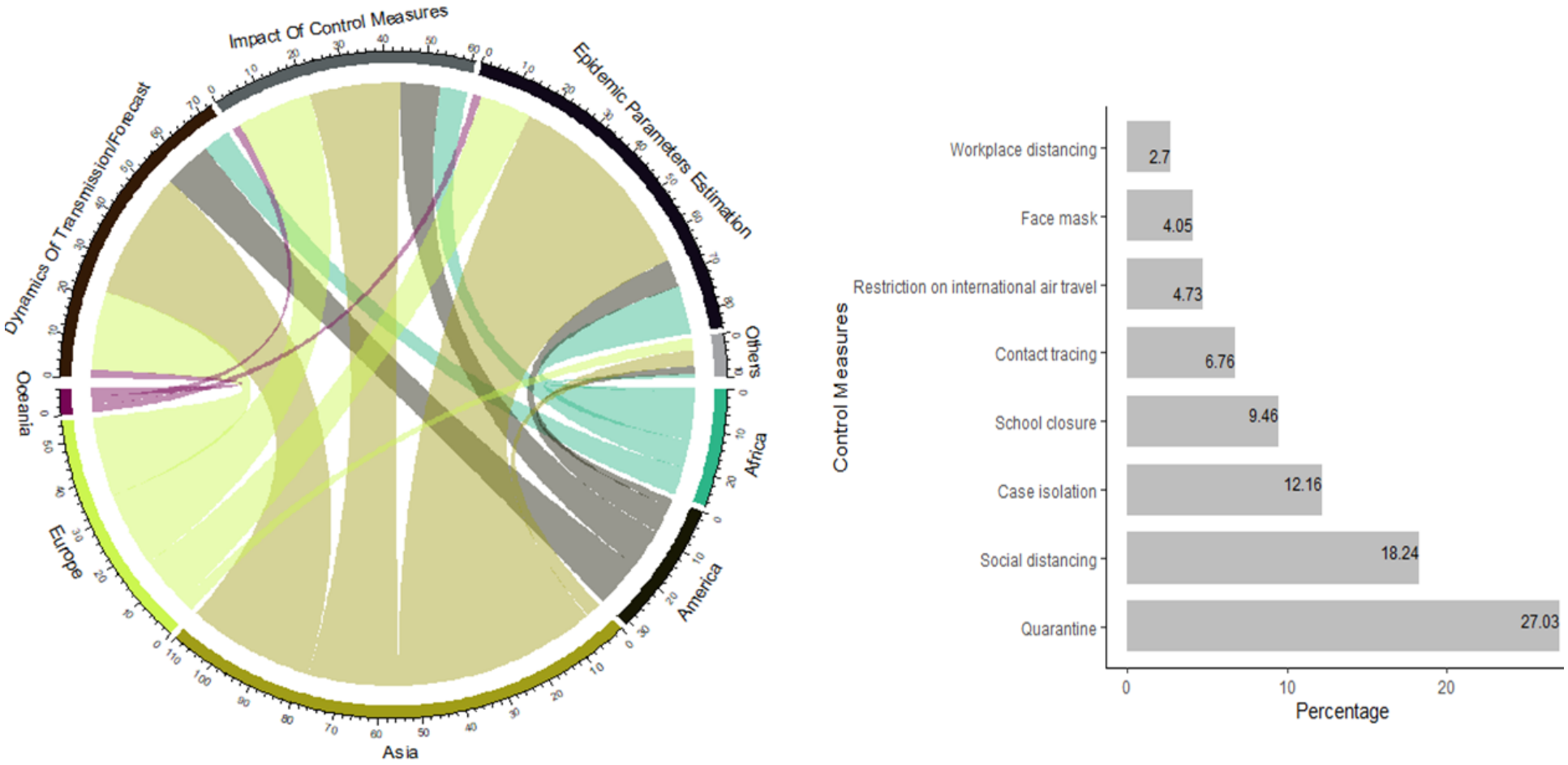

FIGURE 4 – Topics addressed by studies

Results

Modelling techniques

Diversity

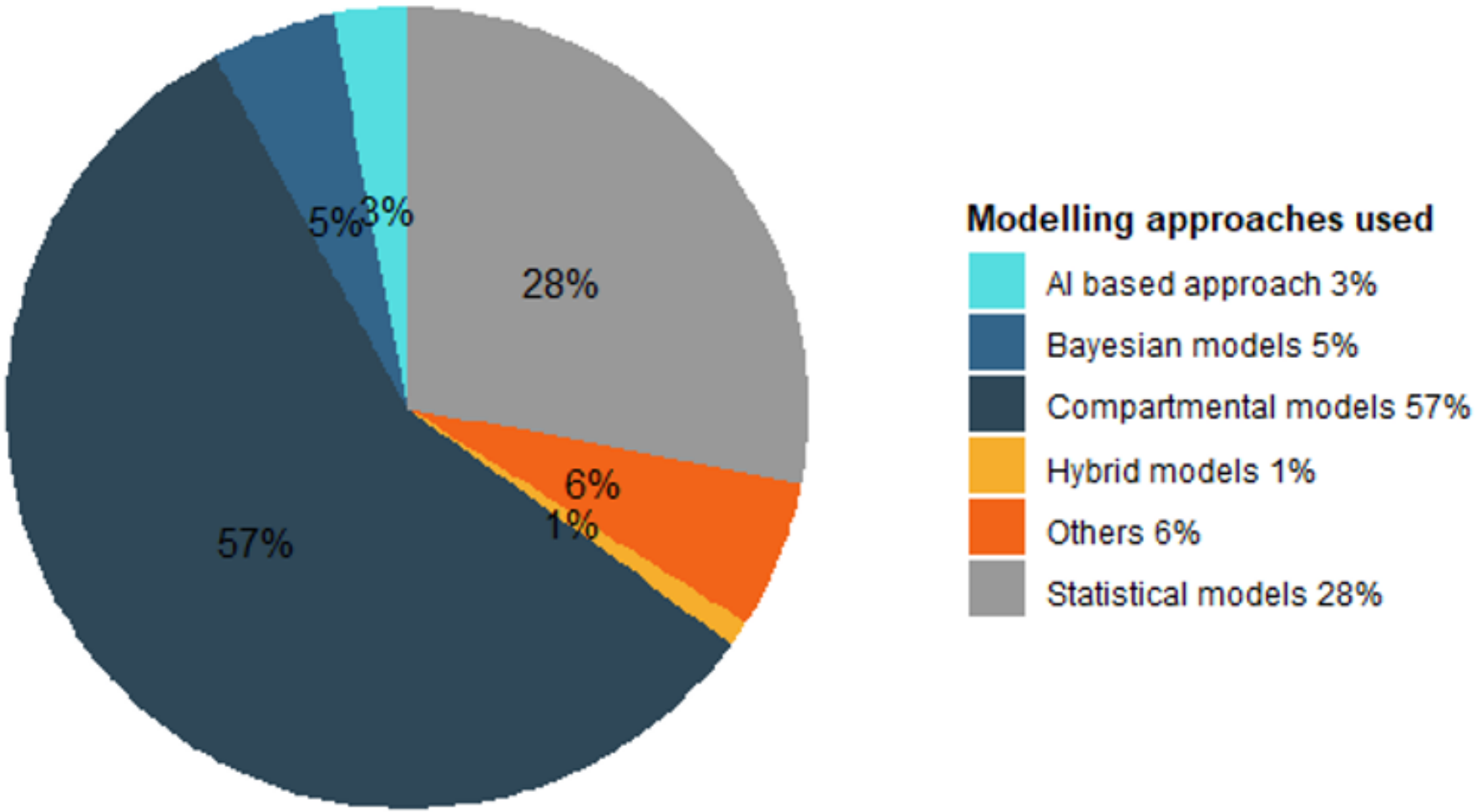

FIGURE 5 – Modelling techniques used

Results

Models	Count
Compartmental Models	
SEIR Model and SEIR Model-like	59
SIR Model and SIR-like model	29
Deterministic compartmental Model stratified by age using Bayesian framework	1
Metapopulation AGe-structured Epidemiological (MAGE) Model	1
Reservoir-People (RP) transmission network Model	1
SUQC Model	1
Healthcare Compartmental Epidemic Model	1
Statistical Models	
Growth models (Exponential Growth Model, Generalized-growth Model, Logistic growth Model Richard Growth Models, Von Bertalanffy Growth Model, Gompertz Model)	26
Time series models (ARIMA/ARIMAX models, Exponential Smoothing, VAR model, Dynamic Time Warping Model Interrupted time series Model, Holt-Winters Models)	14
Regression analysis (Linear Regression, Polynomial Regression Multilevel mixed effects linear regression Models)	8
Spatial regression model (Spatial Error Model, Spatial Error_Lag Model, Spatial Lag Model Geographically weighted regression)	4
Poisson family model	6
Parametric distributions (Weibull, gamma, lognormal) fitting Model	4
Exponential Decay Model	1
Least Squared Error (LSE) Model	1
Model for Serial Interval	1
Probabilistic Model	1
Wallinga and Teunis Model	1

FIGURE 6 – Compartmental and statistical models developed in the 148 studies

Results

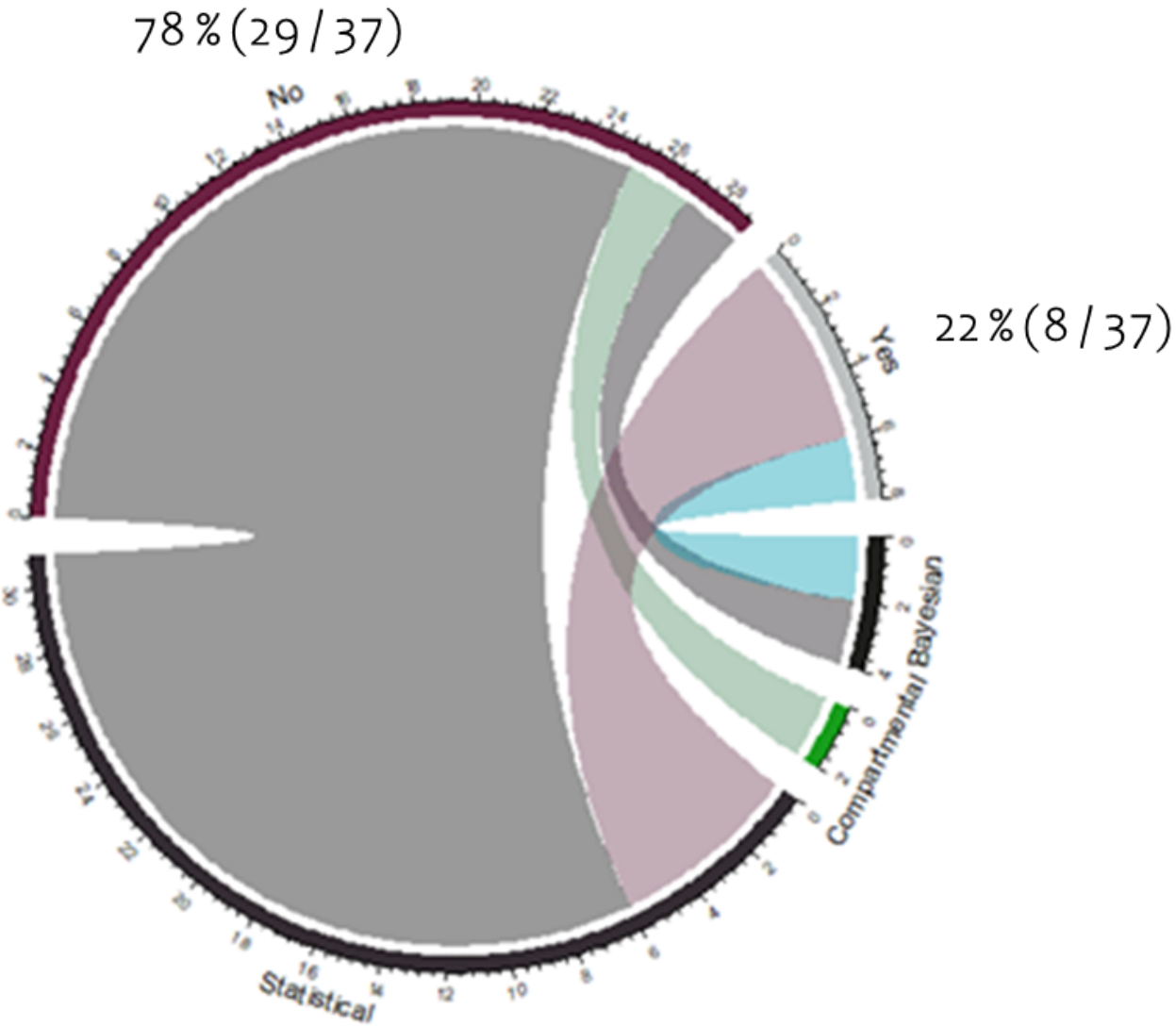

FIGURE 7 – Models used and number of true value of cumulative number of cases in the 95%CI or 95%CrI given in the studies (8 studies for 37 estimations)

Results

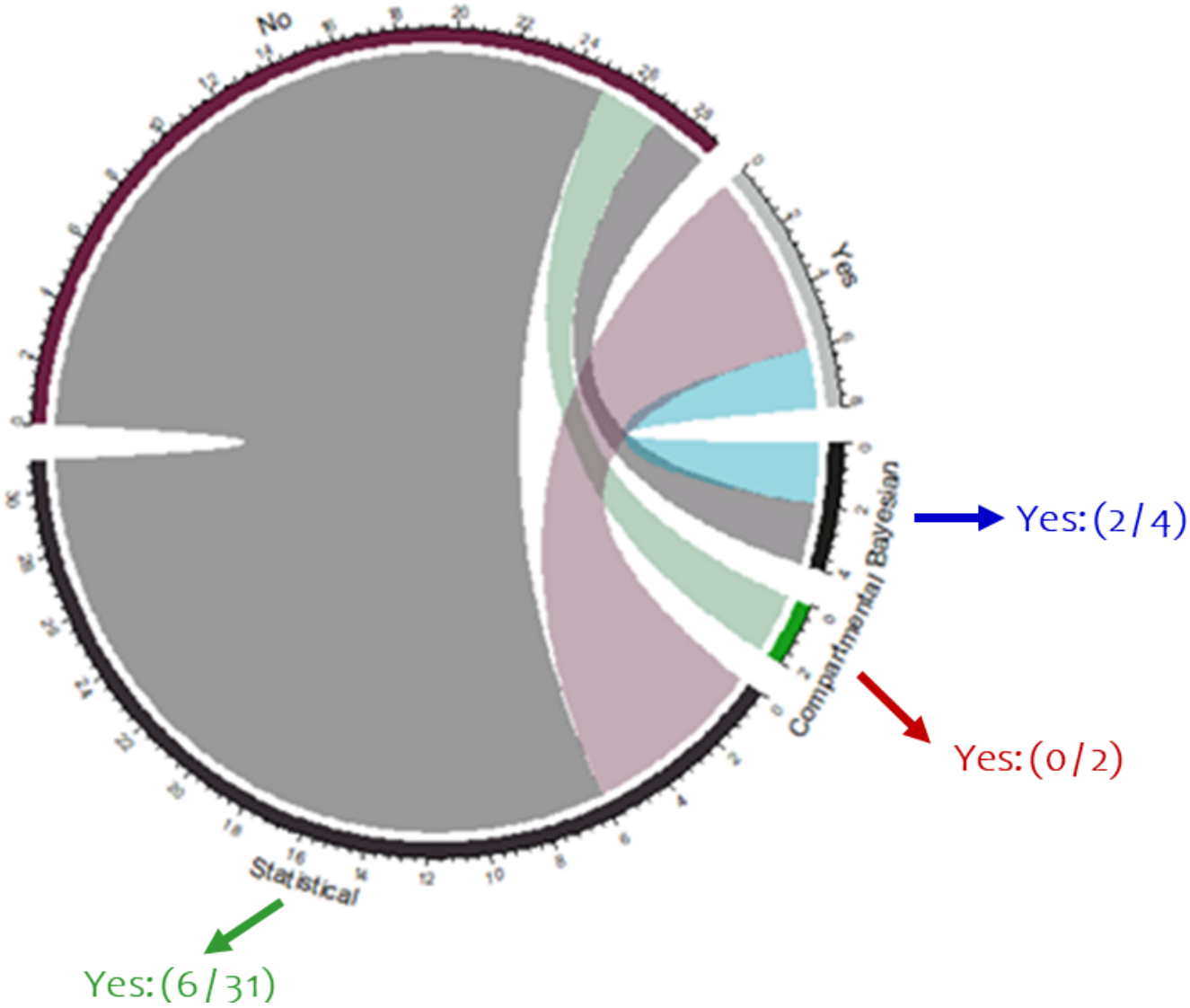

FIGURE 8 – Models used and number of true value of cumulative number of cases in the 95%CI or 95%CrI given in the studies (8 studies for 37 estimations)

Appropriateness of the modelling techniques

- Simple versus complex compartmental models (e.g. SIR versus SEIR) : predictions using more complex models may not be more reliable compared to using a simpler model (Roda et al. 2020) ;
- Models are often deterministic, yet many infectious disease systems are fundamentally individual-based stochastic processes, and are more naturally described by stochastic models (Mick et al. 2015) ;

Discussion and conclusions

Quality of data

- Limited data at early stage of epidemics (under-detection) ;
- Reporting delays and poor documentation : "Biased" data which do not allow to better track the epidemics dynamics ;

Assumptions on epidemiological parameters used in the modelling : models built on strong assumptions that may not hold

- Population characteristics, such as age distribution, percentage of older adults with co-morbidities, and risk factors (e.g., smoking, exposure to air pollution) (Nicholas et al. 2020) ;
- Parameters estimated from data collected in the first affected countries (e.g. China, Italy) used to derive estimates of parameters in other countries (Zareie et al. 2020).

Discussion and conclusions

Possible effects of interventions between time prediction is made and when prediction is realized

- Predictions are among others intended to guide public health policies for controlling spread of epidemics. As such, based on the predictions, different control measures might have been taken which might have allowed to considerably reduce the number of cases).

References

Mick R., Viggo A., Alun L., Lorenzo P. (2015). Nine challenges for deterministic epidemic models. *Epidemics* (10) : 49—53.

Zareie B., Roshani A., Mansournia M.A., Rasouli M.A., Moradi G. (2020). A model for COVID-19 prediction in Iran based on China parameters. *medRxiv*, Cold Spring Harbor Laboratory Press.

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THANKS FOR YOUR KIND ATTENTION