

LONG-TERM EFFECTS OF CHILDREN PNEUMOCOCCUS VACCINATION: AN AGENT BASED APPROACH



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PURPOSE

Dynamical modeling and simulation of the epidemical influence of infant immunization with PCV7 against pneumococci induced serious disease and time depending behavior of carrying rates of the pathogens in nasopharynx using a multi agent based approach.

METHODS

The implemented strategy is a multi agent based model approach with detailed implementation of individual social contacts and direct person to person transmission of the pneumococcal bacteria.

Data sources:

Due to the extended model flexibility a higher number of data sources from different areas can be integrated in the model set up phase (see Figure 2). Thus the confidence intervals get smaller and as a result the error probability decreases.

To get highest quality and flexibility for integration of additional data and/or insights in the future the model is implemented in an hierarchical way (see Figure 3). Each of the four model regions can be refined separately without change in the overall modeling structure.

- Microscopic view
- Clear parameters → higher usability in multi domain working groups
- White Box Modeling
- Dynamical method, using realistic behavior
- Inhomogenous population simulation instead of simplified groups/cohorts

Due to extension of model complexity additional knowledge on data structures for modeling of social behavior and contacts between single persons has to be gathered. Although the following points have to be focused on:

- Sensitivity Analysis
- Calculation power
- Model structure verification

RESULTS

For standard immunization program implementation as advocated by EPAR/EMA the direct influence of the immunization including herd immunity and serotype replacement is measured. For basic simulation runs with realistic parameters for Austria a decrease of 30% of serious diseases is measured. Results for serotype replacement (40-60%) are calculated. In contradiction to other modeling methods this values are dynamical generated by the simulation and not input parameters.

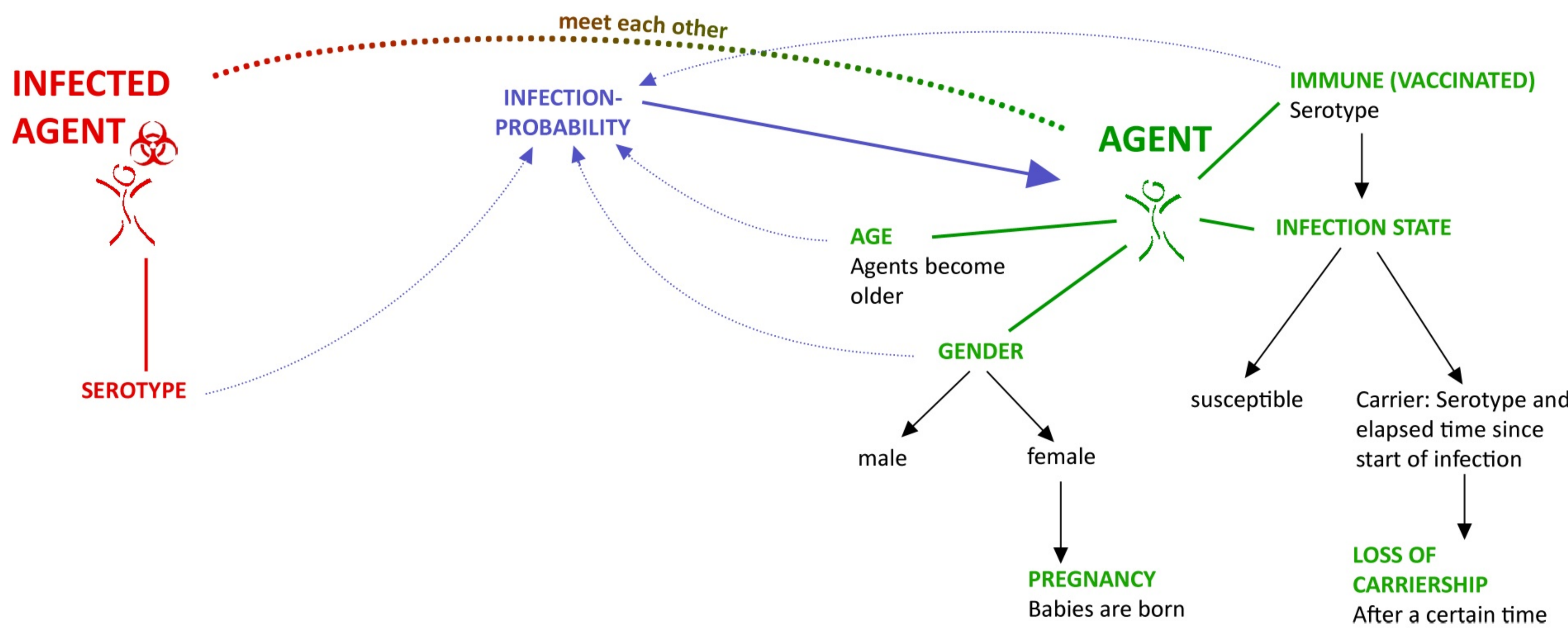


Figure 1. Multi agent structure used in the simulation model. The model uses different states and the interaction of single persons.

To test the influence of different vaccination strategies and the induced non linear effects like herd immunity effects and serotype replacement, strongly influencing the overall effectiveness, additional assumptions are made. Instead of 90 known pneumococcal pathogens only two relevant classes are modeled: the serotypes included in the vaccine and others.

Modular structure:

To realize the problem task a multi agent structure as depicted in Figure 1 is implemented, ensuring high flexibility and the option to model changing demography during simulation time.

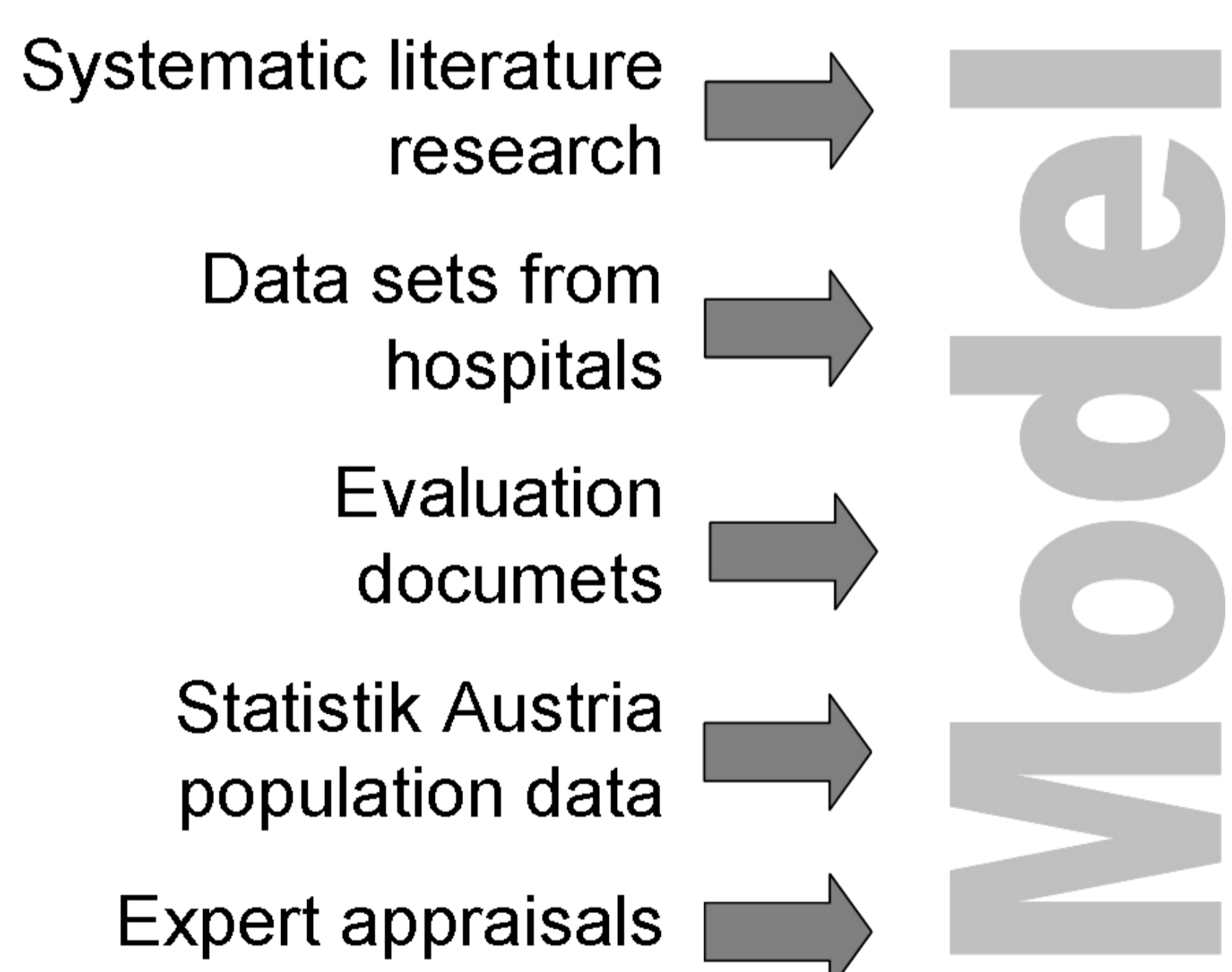


Figure 2. Data sources used for model parameterization and model validation. Different data depth (population level, detailed individual based information, mean values for special age groups or high risk groups) is used in the model parts.

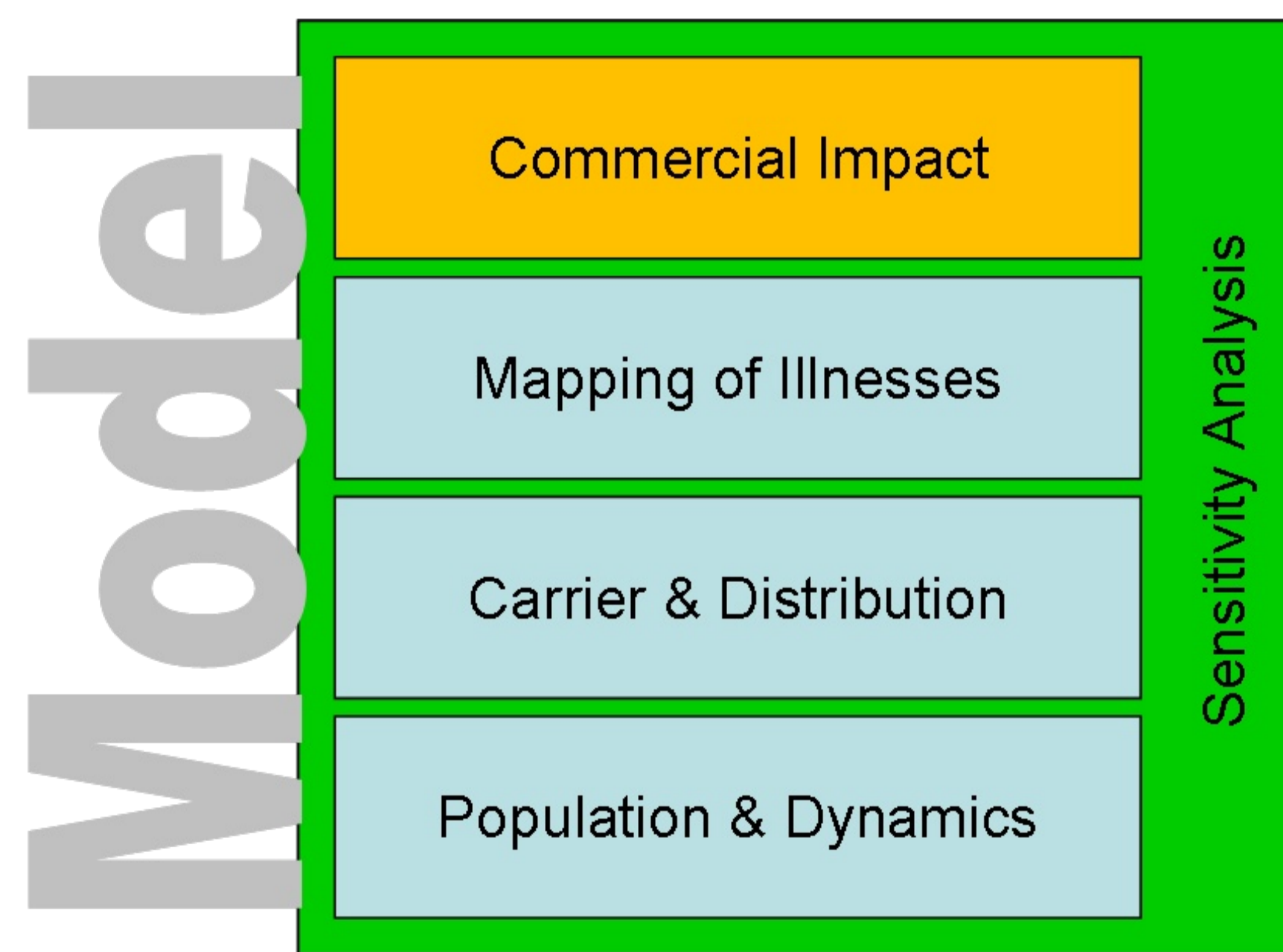


Figure 3. Hierarchical structure of the developed model. Using coupled modeling steps it can be ensured, that the system dynamics and non linearity of the pneumococcal infection in a population can be simulated in detail.

DIFFERENCES/ADVANTAGES OF AGENT BASED MODELS

The following list shows the main differences of an agent based modeling approach for simulation of the spread of pneumococci in the Austrian population in comparison to classical modeling methods and statistics:

Table 1. Results of the base case scenario

Total Costs	~14 Mio. [€ / Year]
Costs per Life Year	224.000 [€ / LYG]
Costs per Case	105.744 [€ / AC]
Number of Avoided Cases per Year	127

CONCLUSION

Agent based modeling leads to detailed information on behavior of the pathogen distribution for all age groups and their changes over time and is thereby a real extension to classical static decision tree based methods in HTA.

The used validated simulation system is dealing with transparent parameters and is better understandable for decision makers in HTA.

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