EMIR
Université de Liège

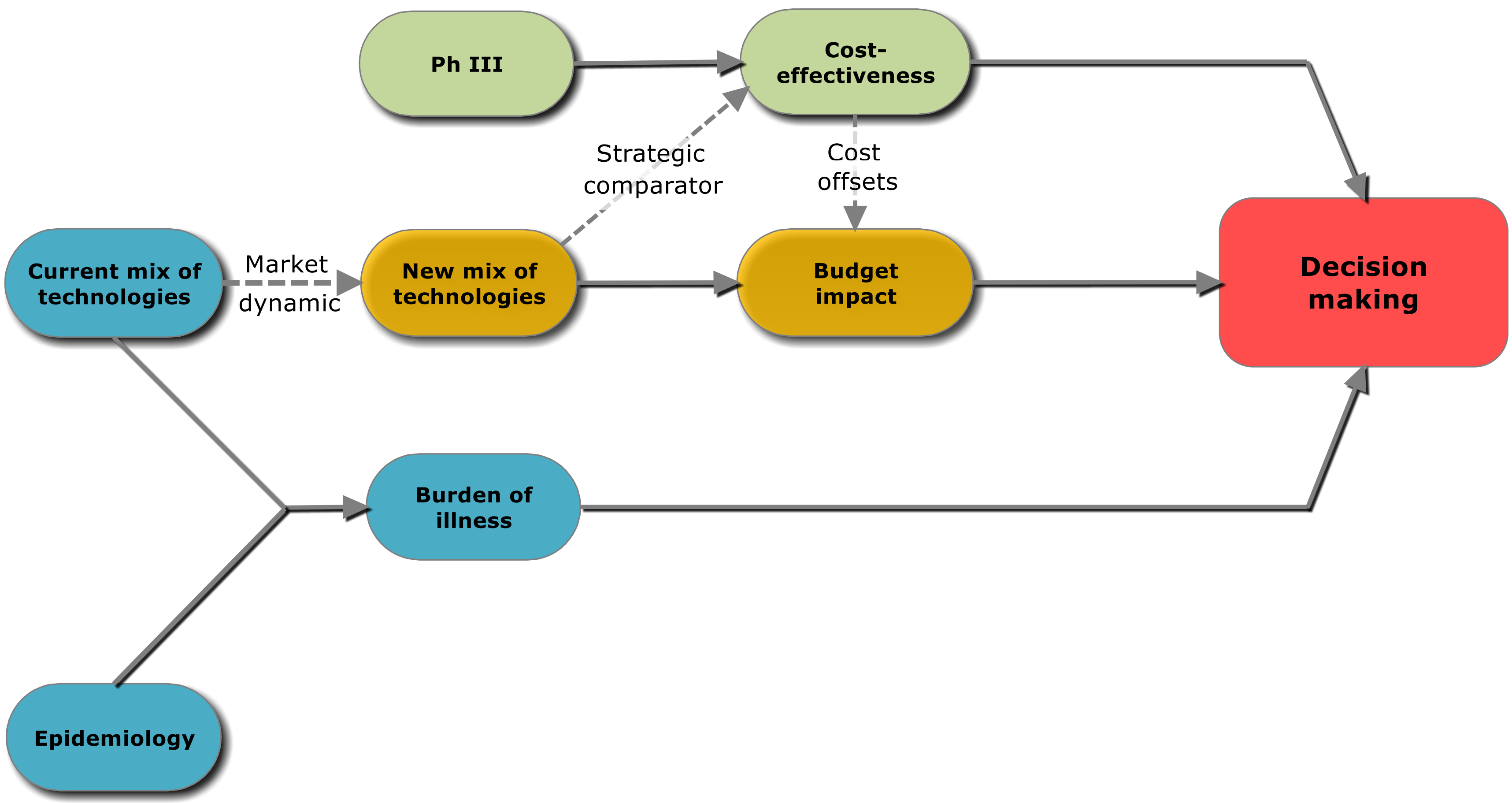
Economic evaluation of **M**edical
Innovation **R**esearch unit

SFES – 22nd January 2015 – Paris, France

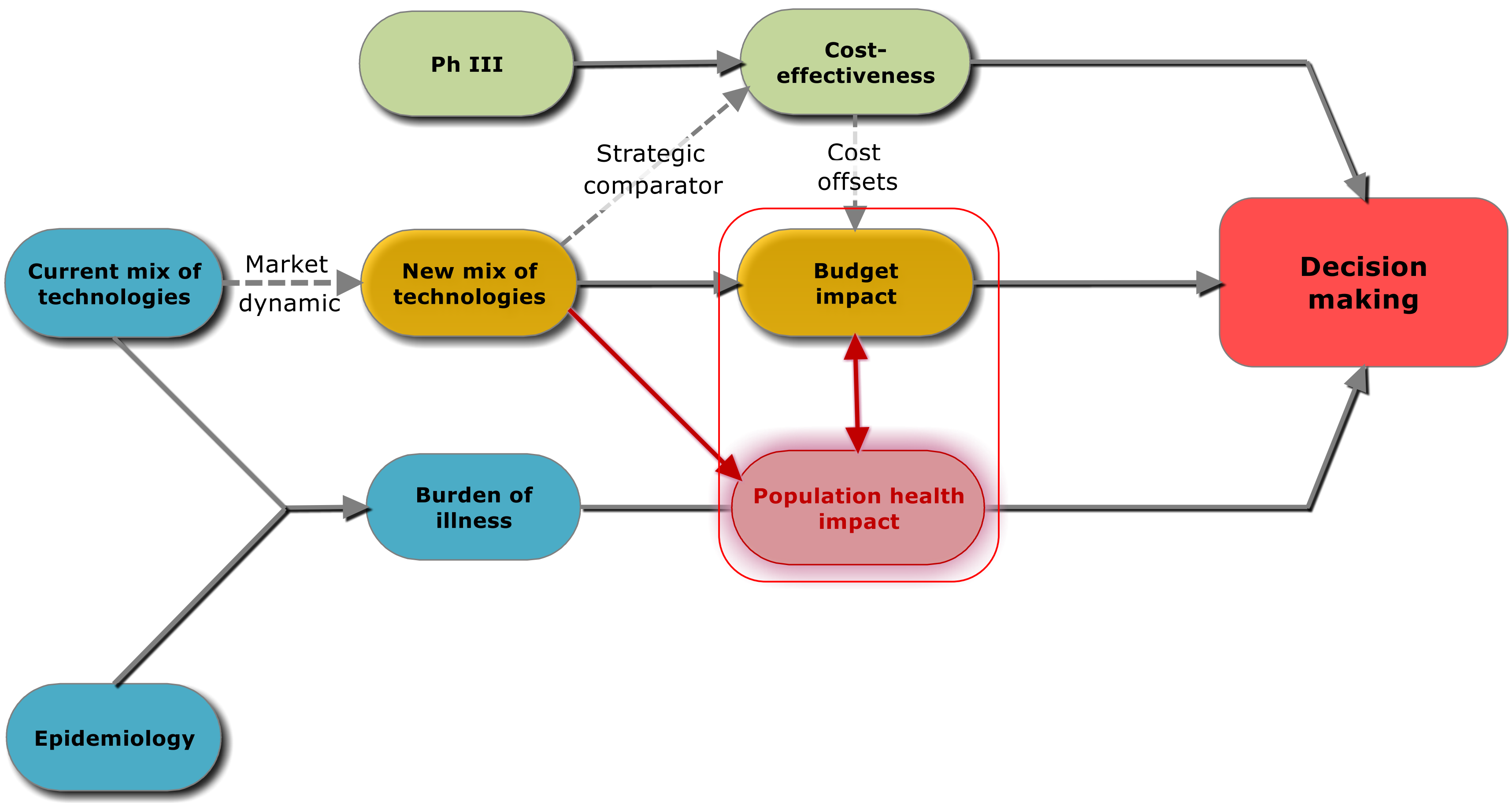
Looking beyond cost-effectiveness to value vaccines in terms of return-on-investment

Olivier ETHGEN *Msc, PhD*

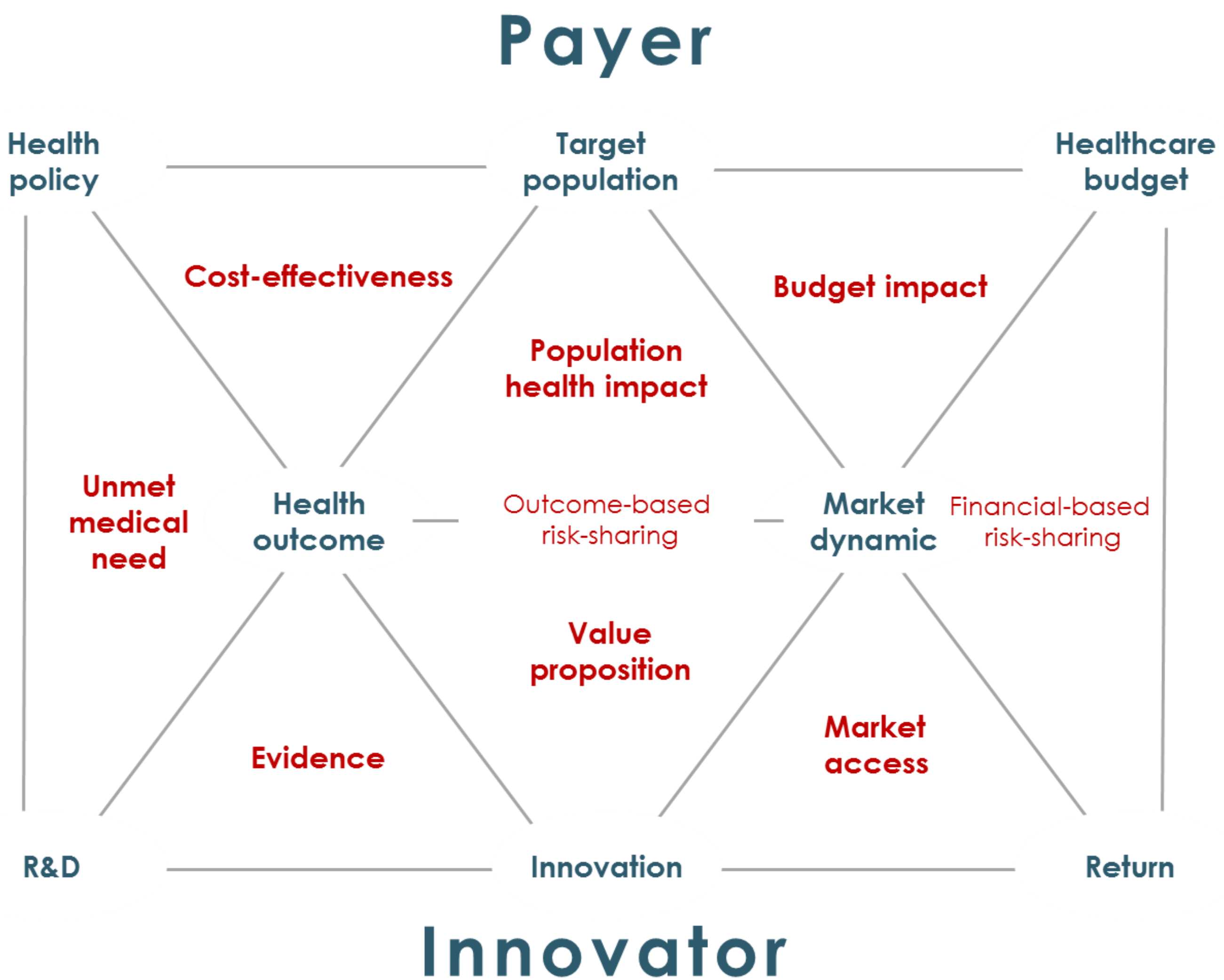
Inform decision-making



Inform decision-making



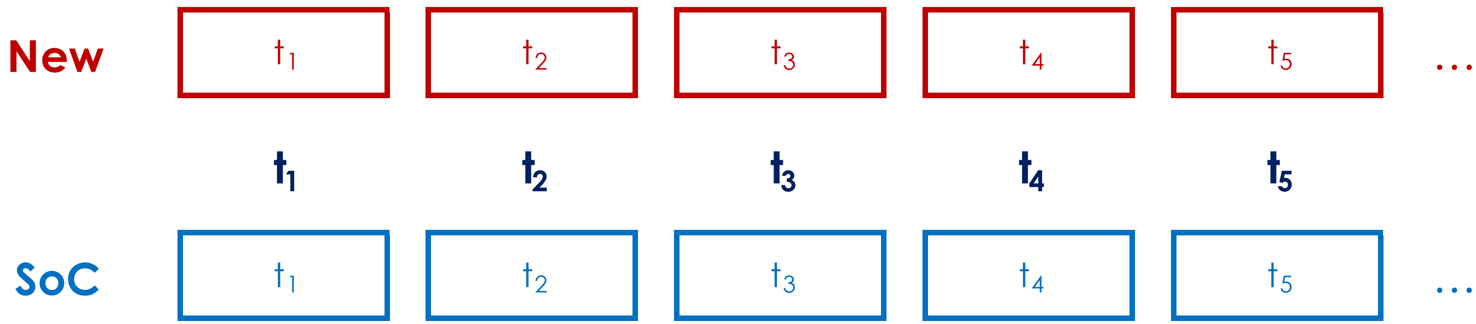
Analytical framework



Public health impact

Cost-effectiveness

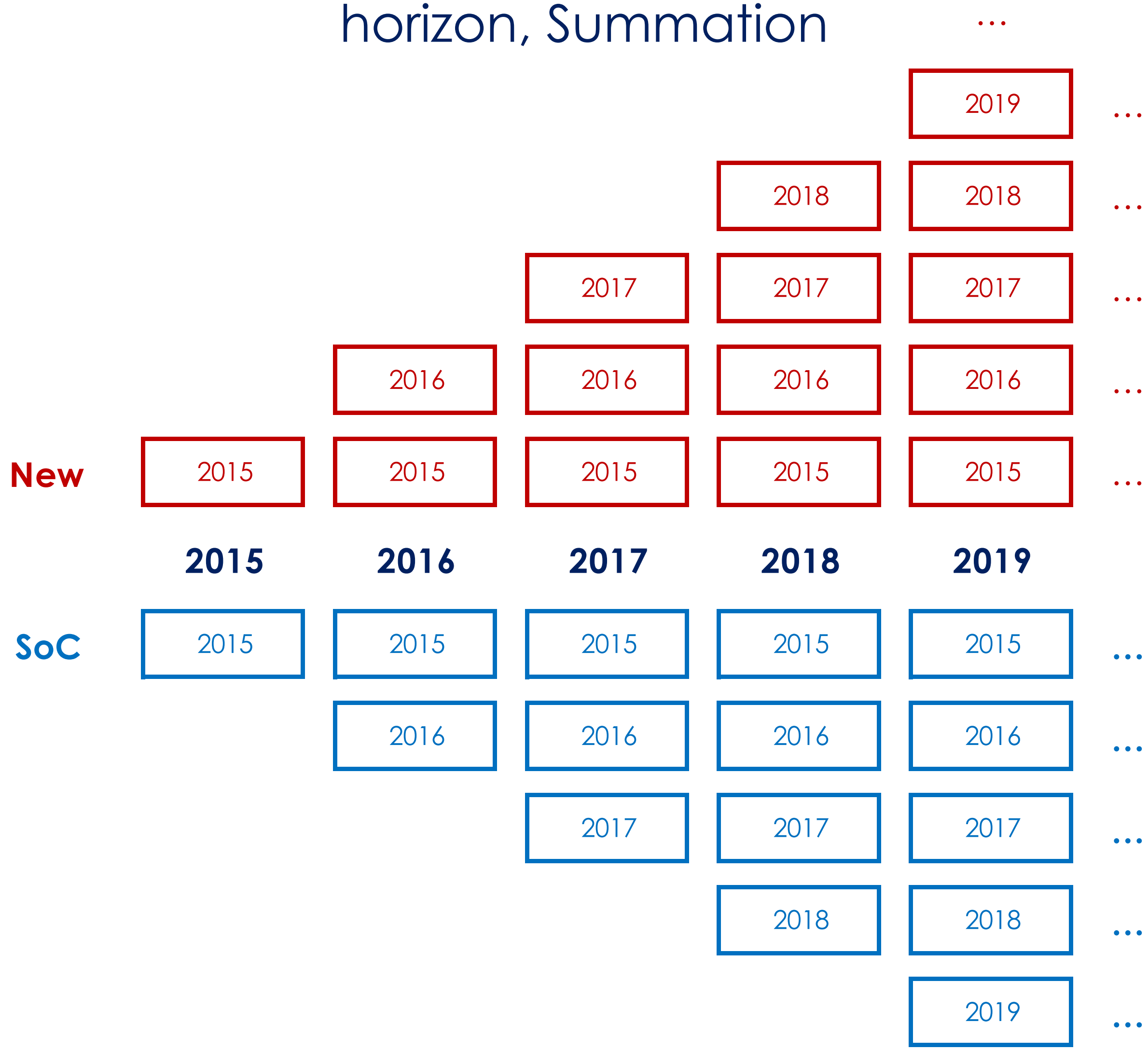
Individual, Cohort, Duration time, Lifetime, Average



Ethgen O et al. *Pharmacoeconomics* 2012; 30:171-81.

Public health impact

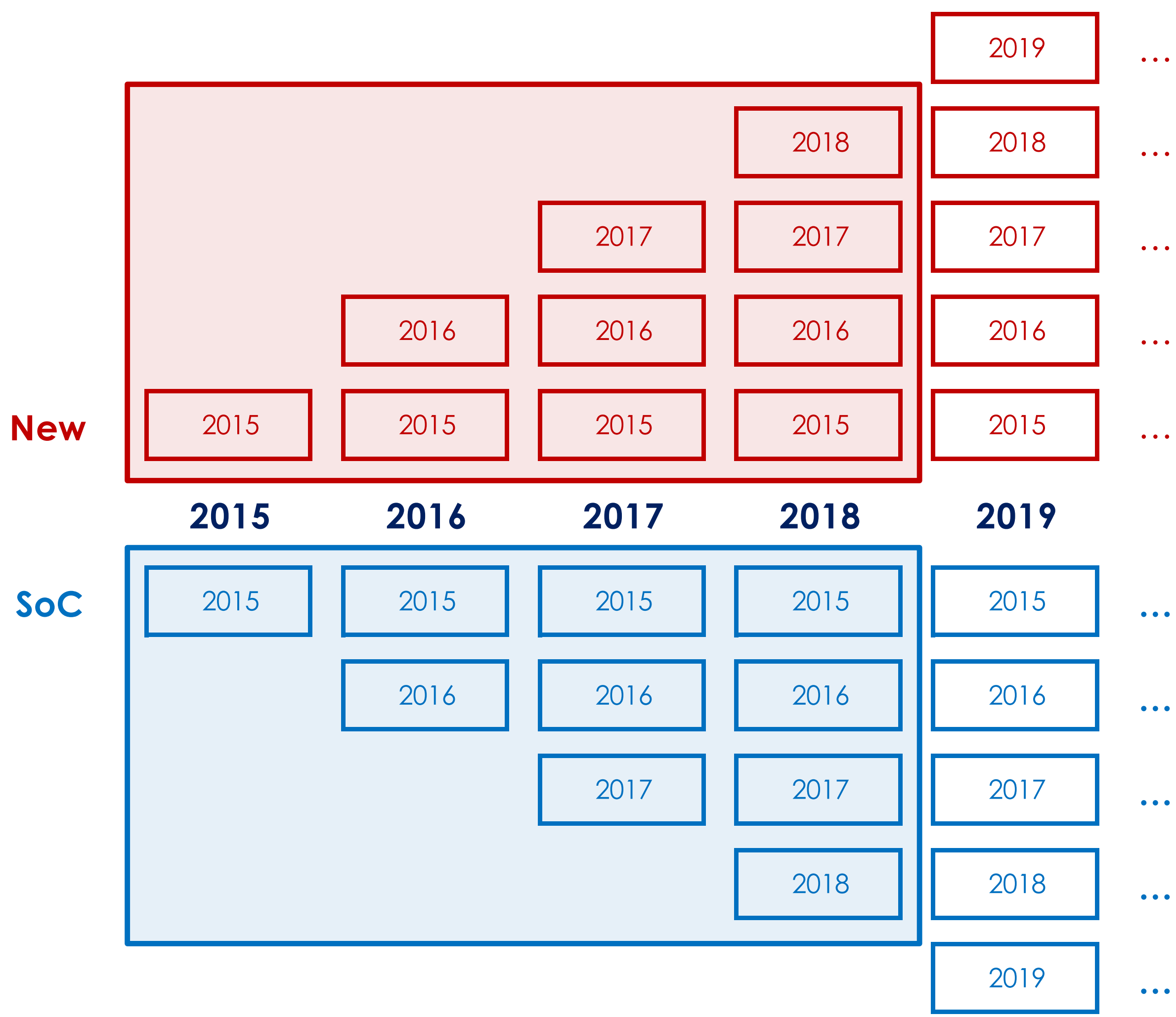
Population, Sequential multi-cohorts, Calendar time, Finite time horizon, Summation



Ethgen O et al. *Pharmacoeconomics* 2012; 30:171-81.

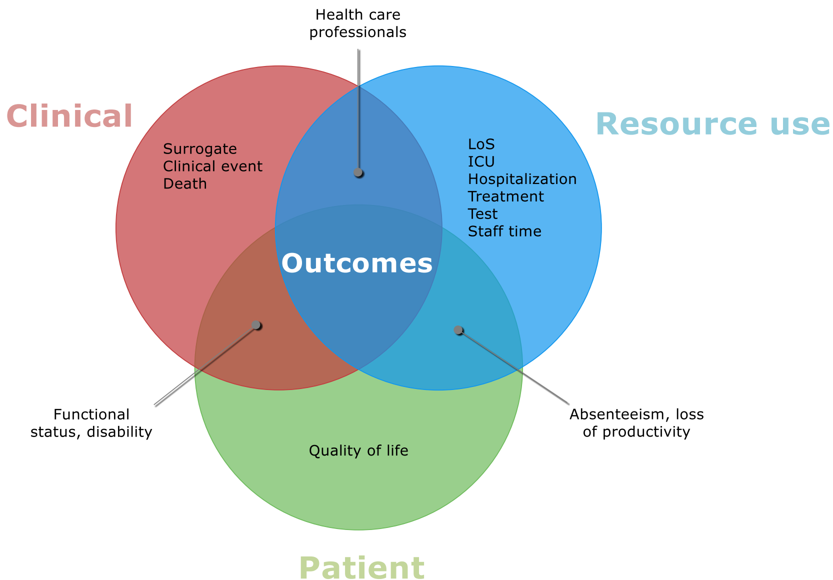
Impacts

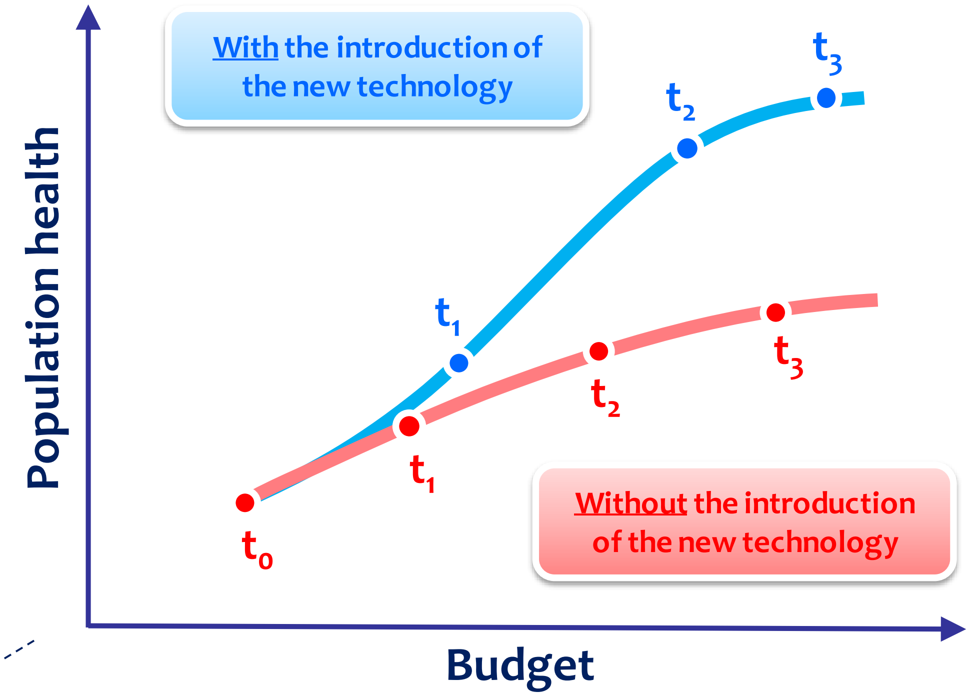
Population, Sequential multi-cohorts, Calendar time, Finite time horizon, Summation



Ethgen O et al. *Pharmacoeconomics* 2012; 30:171-81.

Return





Downstream costs

(Direct and indirect)

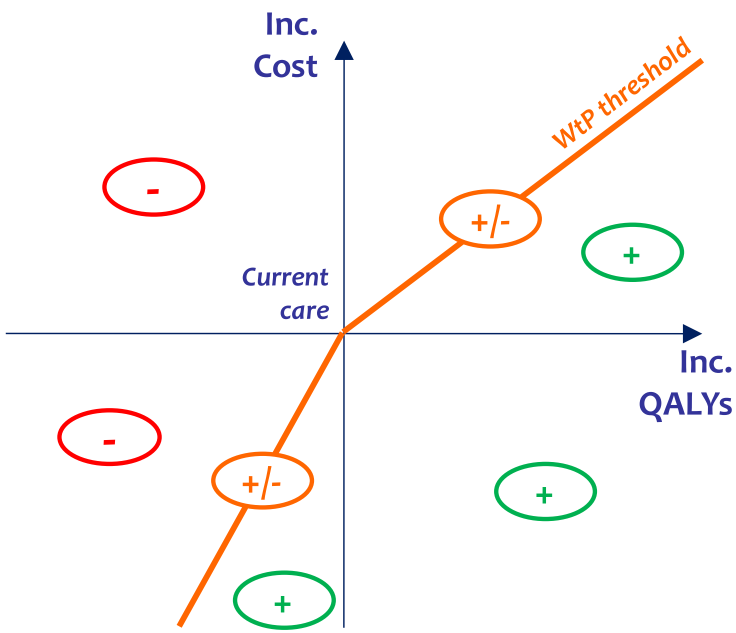
Investment (opportunity cost)

⇨ **The necessary money the payer needs to invest (and/or displace from elsewhere) to fund the implementation of the new technology and that will not be further available for other purposes.**

(Technology acquisition and administration)

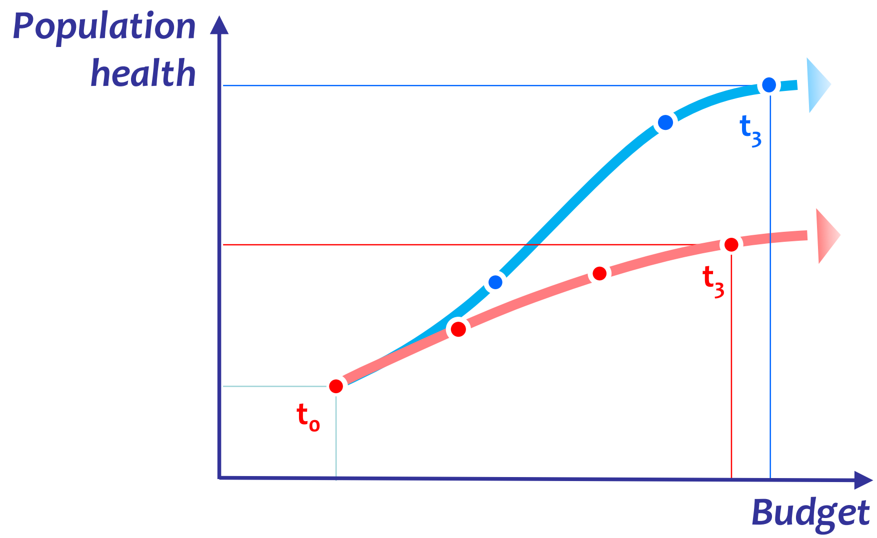
Cost-effectiveness

Individual level



Impacts

Population level



Public health impact and cost-effectiveness of intranasal live attenuated influenza vaccination of children in Germany

Oliver Damm · Martin Eichner · Markus Andreas Rose · Markus Knuf · Peter Wutzler · Johannes Günter Liese · Hagen Krüger · Wolfgang Greiner

Population

The simulated population is based on current demographic data reported by the Federal Statistical Office of Germany [35]. The results of our population forecast are similar to the official results of the 12th coordinated population projection for Germany excluding migration [36]. In the

Time horizon

After a run-in phase of 14 years, using merely current age-specific TIV-coverage rates, the model followed the entire German population over additional 10 years in order to estimate the effects of a supplementary general childhood influenza vaccination in Germany. The analytic horizon of 10 years was chosen to capture introductory effects of the new vaccination policy and to account for seasonal variations in influenza epidemiology.

Damm O et al. *Eur J Health Econ* 2014; DOI 10.1007/s10198-014-0586-4

Table 5 Epidemiological results of the base-case analysis

Undiscounted 10-year outcomes (overall cases across all age groups)	Current policy	Current policy + LAIV-based routine childhood vaccination (2–17 years)	Difference (total cases prevented)	Distribution of avoided cases by age group	
				Under 18 years (%)	18 years and over (%)
Infections	58,863,475	34,958,394	23,905,081	38	62
Symptomatic cases	39,379,665	23,387,166	15,992,499	38	62
Cases of AOM	1,145,311	544,343	600,968	83	17
Cases of CAP	282,447	153,586	128,861	57	43
Deaths	13,960	8,902	5,058	16	84
Prescribed antibiotics	4,172,573	2,490,181	1,682,392	38	62
Hospitalisations	406,297	239,178	167,119	42	58

AOM acute otitis media, *CAP* community-acquired pneumonia, *LAIV* live attenuated influenza vaccine

Damm O et al. *Eur J Health Econ* 2014; DOI 10.1007/s10198-014-0586-4

Table 6 Summary of the cost analysis using base-case estimates

Cost category	Discounted 10-year costs (€)		
	CP	CP + RCHV	Difference
Direct medical costs of vaccination against influenza (TPP)			
TIV	1,872,816,214.16	1,701,799,776.42	−171,016,437.72
Administration of TIV	1,170,510,133.83	1,063,624,860.26	−106,885,273.57
LAIV	0.00	791,516,964.16	791,516,964.16
Administration of LAIV	0.00	262,916,474.11	262,916,474.11
Treatment of LAIV-associated adverse events	0.00	57,983,157.76	57,983,157.76
Direct medical costs of treating influenza-related diseases (TPP)			
Outpatient medical treatment	239,528,399.93	137,833,556.65	−101,694,843.28
Outpatient pharmaceutical treatment	47,278,534.57	26,436,026.60	−20,842,507.97
Inpatient treatment	759,862,529.73	446,500,962.87	−313,361,566.86
Transfers and indirect costs			
Transfers (Kinderpflegekrankengeld)	302,065,027.59	119,571,107.09	−182,493,920.50
Indirect costs in terms of production losses	10,708,705,718.42	6,997,244,130.30	−3,711,461,588.12
Total costs			
Narrow TPP perspective	4,089,995,812.19	4,448,611,778.81	398,615,966.62
Broad TPP perspective	4,392,060,839.78	4,608,182,885.90	216,122,046.12
Societal perspective (including co-payments and indirect costs)	15,042,784,059.11	11,639,184,713.27	3,403,599,345.84

CP current policy, *RCHV* LAIV-based routine childhood vaccination (2–17 years), *TPP* third-party payer, *TIV* trivalent inactivated influenza vaccine, *LAIV* live attenuated influenza vaccine

Damm O et al. *Eur J Health Econ* 2014; DOI 10.1007/s10198-014-0586-4

A public health and budget impact analysis of vaccinating the elderly and at-risk adults with the 23-valent pneumococcal polysaccharide vaccine or 13-valent pneumococcal conjugate vaccine in the UK

Expert Rev. Pharmacoecon. Outcomes Res. 14(6), 901–911 (2014)

Yiling Jiang*[1], Aline Gauthier[1], Sam Keeping[2] and Stuart Carroll[2]

[1]Amaris, The Fitzpatrick Building, 188 York Way, London N7 9AS, UK
[2]Sanofi Pasteur MSD, Mallards Reach Bridge Avenue, Maidenhead, Berkshire SL6 1QP, UK
*Author for correspondence: yjiang@amaris.com

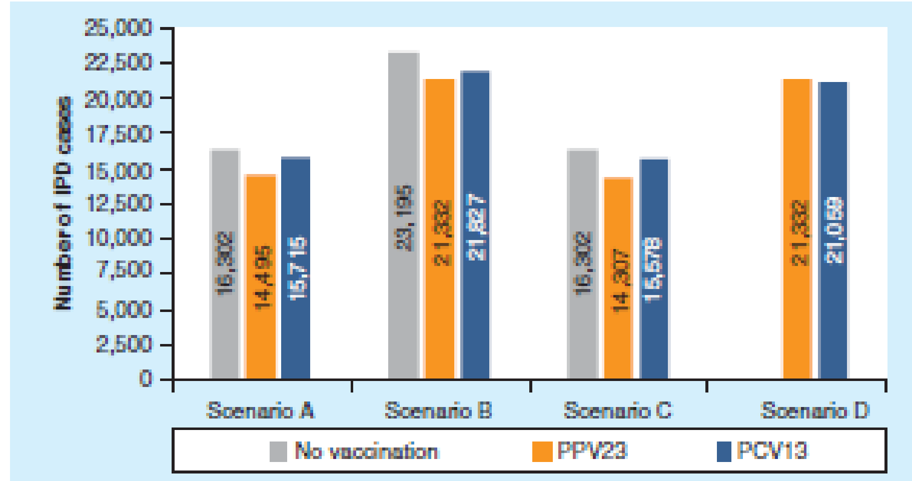


Figure 4. Total number of invasive pneumococcal disease cases.
IPD: Invasive pneumococcal disease; PCV: Pneumococcal conjugate vaccine; PPV: Pneumococcal polysaccharide vaccine.

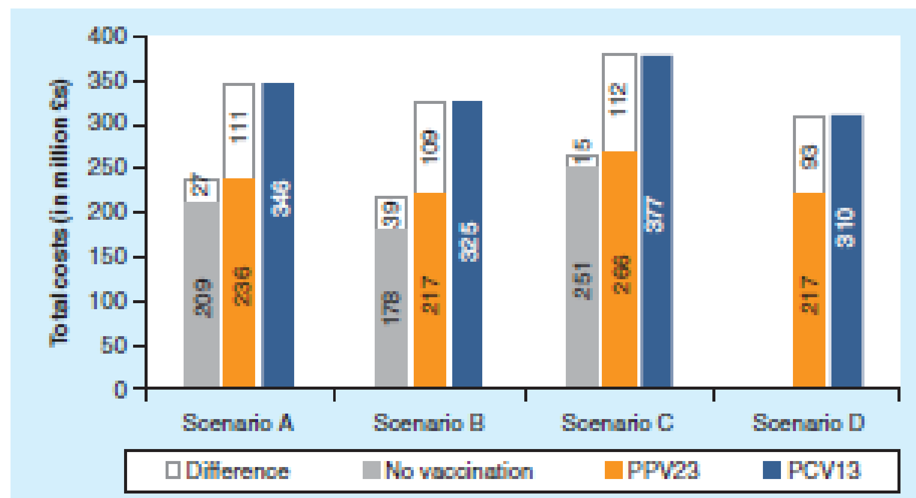
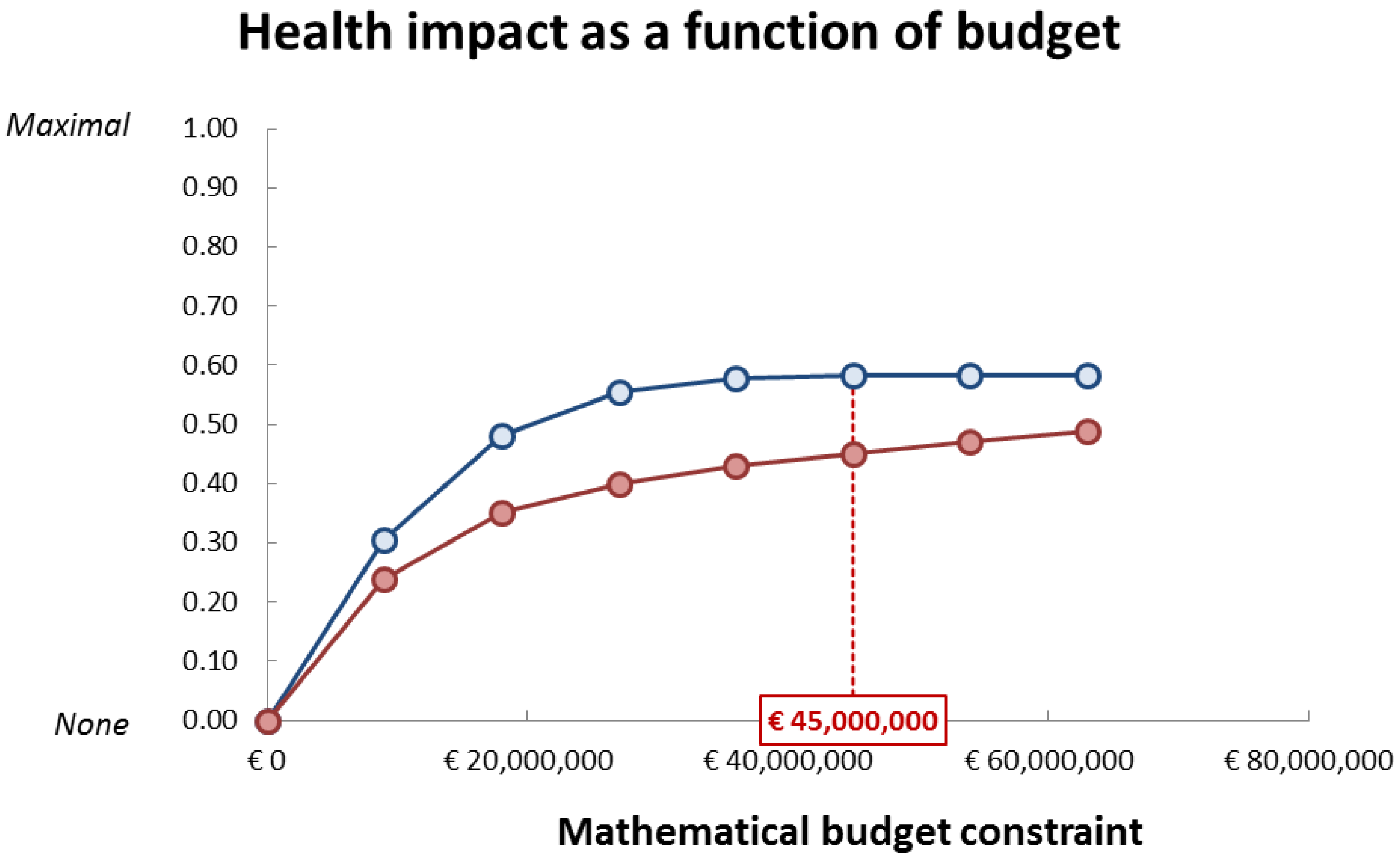


Figure 5. Total budget and budget impact.
PCV: Pneumococcal conjugate vaccine; PPV: Pneumococcal polysaccharide vaccine.

Jiang Y et al. *Expert Rev Pharmacoecon Outcomes Res* 2014;14:901-11.

MCDA & Optimization



Fiscal return

Fiscal perspective

Figure 1. Example of typical fiscal life course reflecting age-specific per capita transfer costs and receipts

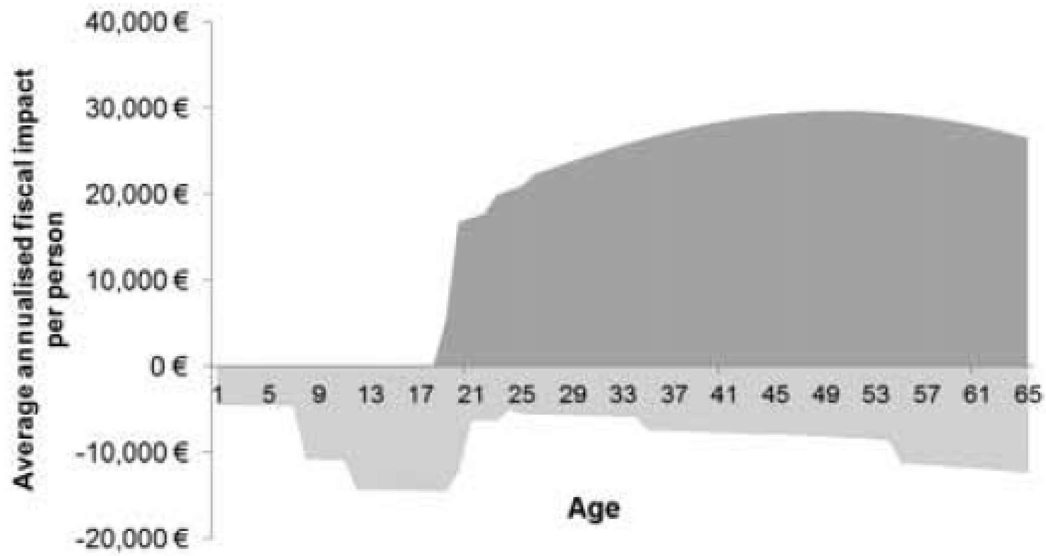


Table 1. Fiscal consequences of poor health in working-aged populations United Kingdom (Black, 2008)

		Annual cost to government Billion £ (2007)	Percentage Government Cost
Workless benefits	Cost	£29	43%
Healthcare	Cost	£5 - £11	11%
Foregone taxes	Revenue loss	£28 - £36	46%
Total costs to government		**£62 - £76**	

Connolly M et al. *ISPOR Connections* 2013;19:16-17.

Fiscal consequences of changes in morbidity and mortality attributed to rotavirus immunisation

Nikolaos Kotsopoulos [a,b], Mark P. Connolly [a,b,*], Maarten J. Postma [a], Raymond C.W. Hutubessy [c]

Net taxes represent the difference between lifetime taxes paid after deducting lifetime direct transfers received. In the model all taxes and transfers are age-specific to represent the fiscal life course and the point of time at which fiscal transactions occur. In summary, in early ages of life the immunised and unimmunised cohorts are net recipients of government transfers in the form of healthcare and education. As the cohorts age and reach working age the cumulative gross taxes increase and government transfers are minimal. The model horizon was set at 65 years from birth. This age cut-off point was used since there was limited data on average earnings, pensions and consumption in later ages. The costs of rotavirus immunisation are treated as an investment that appears in the transfer costs for these cohorts.

Therefore, to reflect the present value of investing in rotavirus vaccination, we estimate the net present value (NPV) and the downstream lifetime taxes and transfers of the immunised cohort as follows:

Kotsopoulos N et al. *Vaccine* 2013;31:5430-4.

$$\text{NPV} = \frac{\Sigma^T (R_t - E_t)}{(1+r)^t - K_0(t)}$$

R_t = sum of gross taxes paid

E_t = sum of age-specific direct government expenditure per cohort over lifetime (e.g., education, healthcare)

r = rate of discount

T = current life expectancy

K_0 = vaccine purchasing costs.

Kotsopoulos N et al. *Vaccine* 2013;31:5430-4.

Ghana

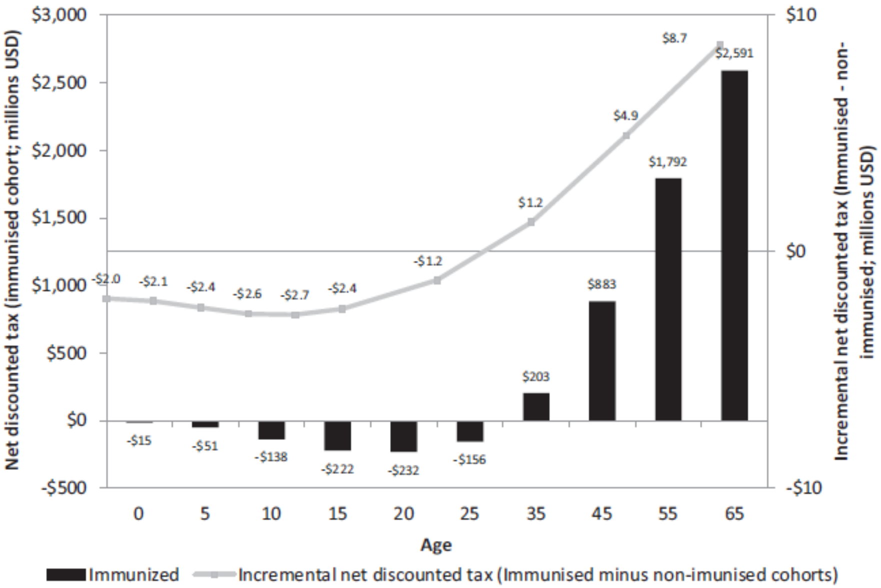


Fig. 1. Discounted net tax revenue for immunised cohorts ($n = 528{,}887$) in Ghana up to age 65 in millions USD [left *Y*-axis] and incremental net discounted tax between immunised and non-immunised cohorts [right *Y*-axis].

Vietnam

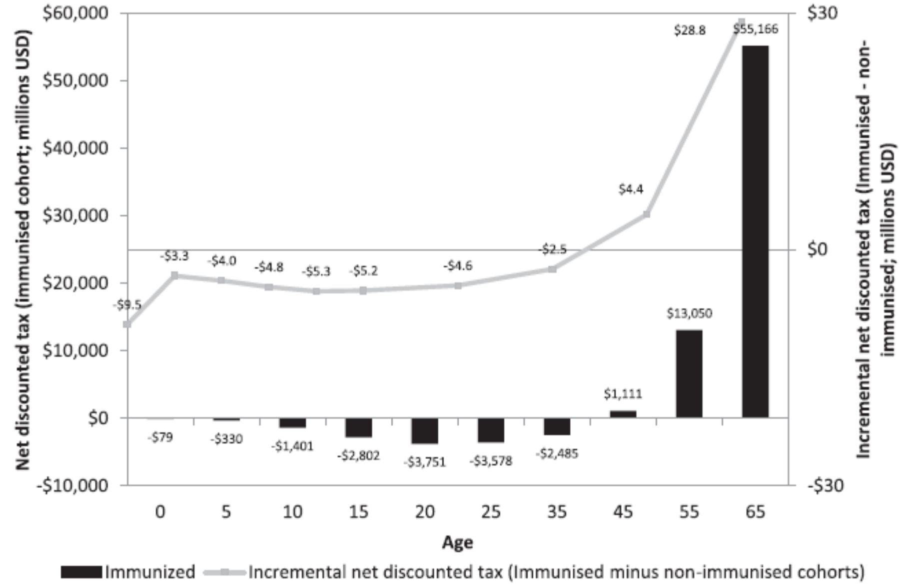
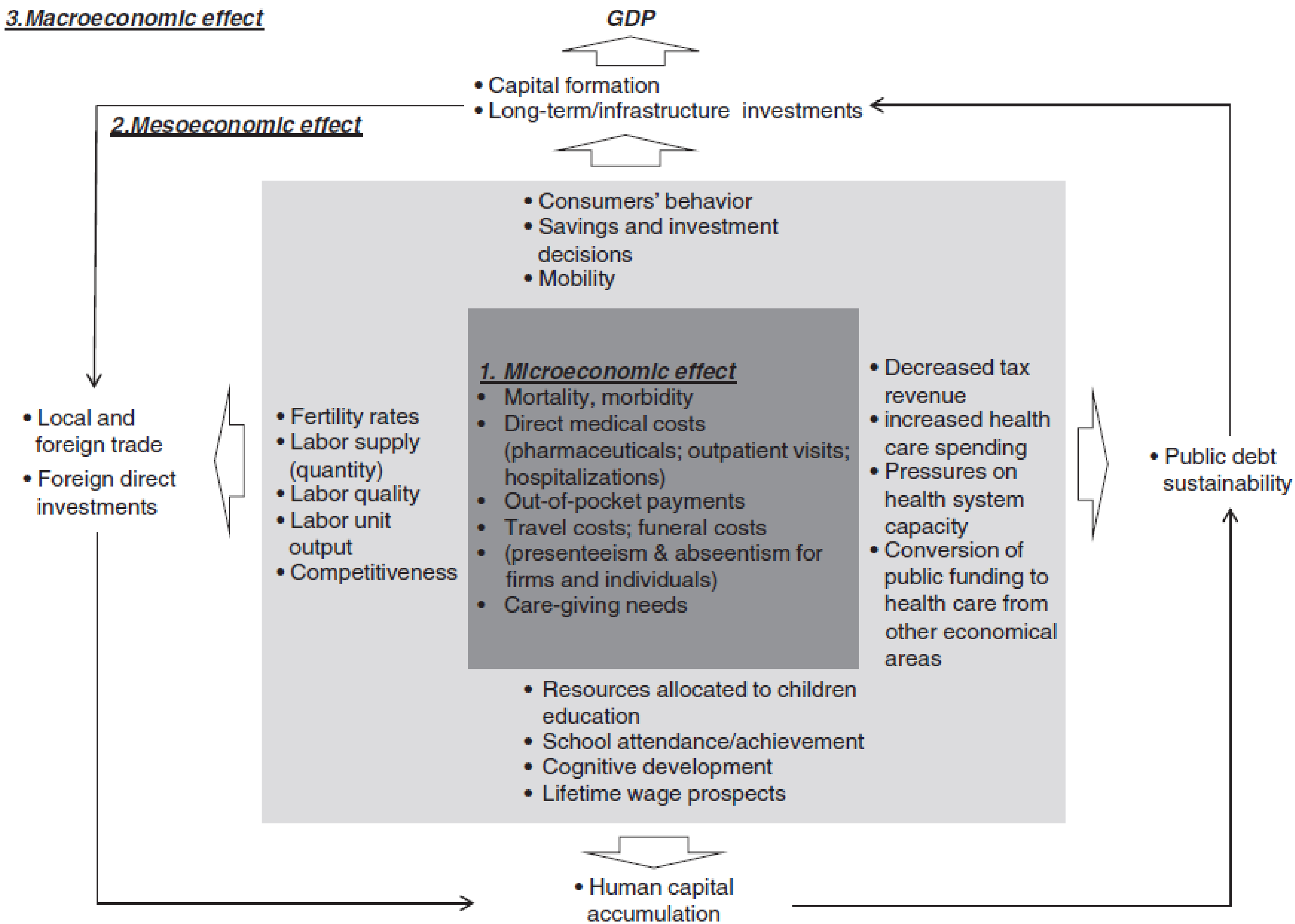


Fig. 2. Discounted net tax revenue for immunised cohorts ($n = 1{,}485{,}000$) in Vietnam up to age 65 in millions USD [left *Y*-axis] and incremental net discounted tax between immunised and non-immunised cohorts [right *Y*-axis].

Kotsopoulos N et al. *Vaccine* 2013;31:5430-4.

Macroeconomic effect

Communicable diseases and the economy



Kotsopoulos N et al. *J Market Access Health Pol* 2014;2:23897

Micro- *vs.* Macroeconomic methods

Table 1. Micro- and macroeconomic methods for evaluating vaccine indirect costs

Characteristics	Microeconomic methods: Cost of illness – CEA	Microeconomic methods: Indirect	Microeconomic methods: Contingent valuation	Macroeconomic methods: Econometric	Combined micro- & macro: CGE models
Scope of evaluation	Technical efficiency of alternative health care interventions	Societal loss associated with disease prevention	Societal preferences for disease prevention and the relative importance of its attributes	Statistical association of communicable disease epidemiology with GDP or GDP per capita	Cross-sectorial microeconomic and macroeconomic impact of disease prevention
Evidence and analysis needs	Decision analytic modeling combining epidemiological data, resource use and unit costs; absenteeism, and presenteeism (optional)	Cohort modeling of epidemiological data, wages, absenteeism, and presenteeism	Survey collection and analysis methods	Econometric models to model retrospective panel data for GDP, epidemiology and a set of control variables	Sectorial matrix CGE models to simulate the consequence of disease on economic behaviors and productivity
Vaccinations' benefit	Reduction of mortality and morbidity; Improvement of Patient quality of life; Prevention of health care costs; productivity gains and care-giving needs reduction	Reduction of sick-days; Increase of productivity while at work; Increase in total productive life years; increase in education levels achieved and lifetime education-specific earnings	Vaccinations are associated with positive WTP for preventing disease	Vaccination benefit can be quantified if vaccination variables are included in the model and vaccination data available	Change of economic behavior patterns projected/ investment choices
Decision criterion	ICERs in terms of cost/LY or QALY or DALY gained or cases averted	Inclusion in CEA or CBA	NPV: WTP for prevention of disease minus the cost of vaccination	Statistical relationship between GDP and vaccination	GDP impact of disease prevention; income, productivity gain, income distribution
Incorporation of broader consequences	Optional inclusion of absenteeism and presenteeism evaluations for the individual and the firm	Absenteeism and presenteeism evaluations for the individual and the firm; Quantification of the statistical and fiscal value of future cohorts (demographical changes); May link education outcomes with lifetime earnings	Depending on the survey design it may assess intangible elements that influence individuals' decisions	Retrospective analysis implicitly captures all levels	Projections of the macroeconomic consequences are based on assumptions or data relating to broader consequences
Policy relevance/ utility	Efficient allocation of resources within the health care budget	Comprehensive estimate of the economic surplus produced for the society	Identify societally preferred health policies	Ad-hoc assessment of cross – country macroeconomic association between the disease and the GDP; Cross-country best practice identifications	Cross-sectorial allocation of funding; Public investment appraisals

Kotsopoulos N et al. *J Market Access Health Pol* 2014;2:23897

CGE model

Computable General Equilibrium

Computable general equilibrium model—A mathematical model of the whole economy that includes the cost minimising and profit maximising behaviour of producers, the consumption and saving behaviour of households and government, taxation mechanisms, and the use of labour, capital, and other factors in order to produce goods for investment or consumption. The model produces a benchmark solution which is then compared with alternative solutions incorporating policy change or other events simulated by the model. Counterfactual solutions can be compared with the benchmark solution to estimate the economic impact of the simulated policy or event.

Smith RD et al. *BMJ* 2009;339:b4571.

The economy-wide impact of pandemic influenza on the UK: a computable general equilibrium modelling experiment

Richard D Smith, professor of health system economics,[1] Marcus R Keogh-Brown, research fellow in economic modelling,[1] Tony Barnett, professorial research fellow and honorary professor,[1,2] Joyce Tait, professor and scientific adviser[3]

Social accounting matrix—A matrix that represents the balanced income and expenditure flows of a regional, national, or global economy aggregated to make them a manageable size for use in a computable general equilibrium model. (The matrix rows represent income to the economy and the columns represent expenditure.)

Global trade model—A computable general equilibrium model of the global economy.

PA **Prophylactic absenteeism**—Absence from work of a healthy individual in order to avoid infection.

Clinical attack rate—The percentage of individuals in a population who become infected.

Case fatality rate—The percentage of infected individuals who die.

Mortality rate—Percentage of individuals in a total population who die (clinical attack rate × case fatality rate).

Reactive school closure—Government closure of a school to reduce infection when a (government defined) proportion of children or staff is experiencing illness.

SC **School closure associated with prophylactic absenteeism**—Closure of schools caused by the amount of prophylactic absence by staff.

Transition point—The point at which the severity of the pandemic provokes sufficient fear to invoke a sudden increase in prophylactic absenteeism within the population.

Smith RD et al. *BMJ* 2009;339:b4571.

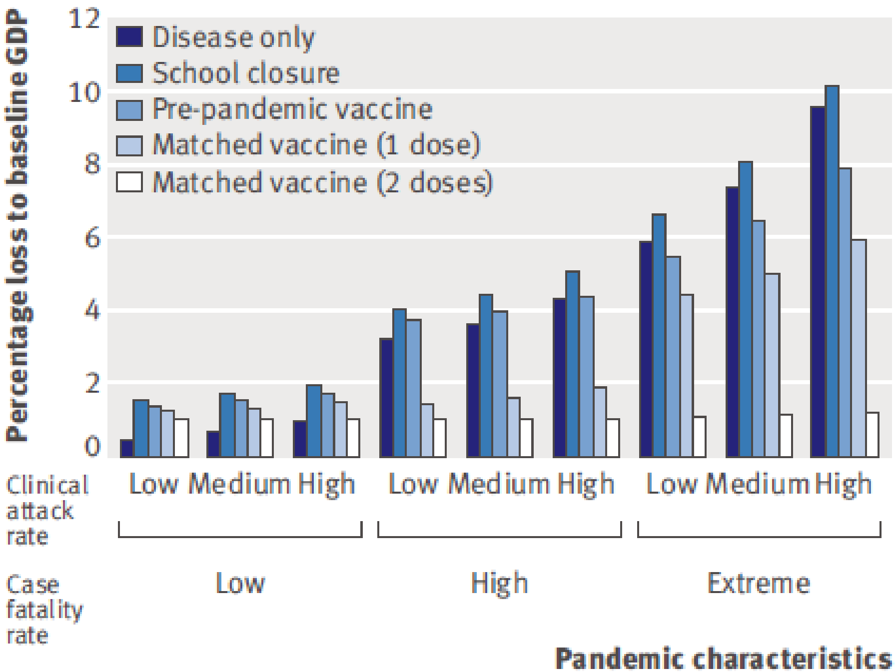


Fig 1 | Effect of pandemic influenza on UK gross domestic product (GDP) according to various disease and mitigation scenarios (all vaccination strategies assumed to have 60% coverage)

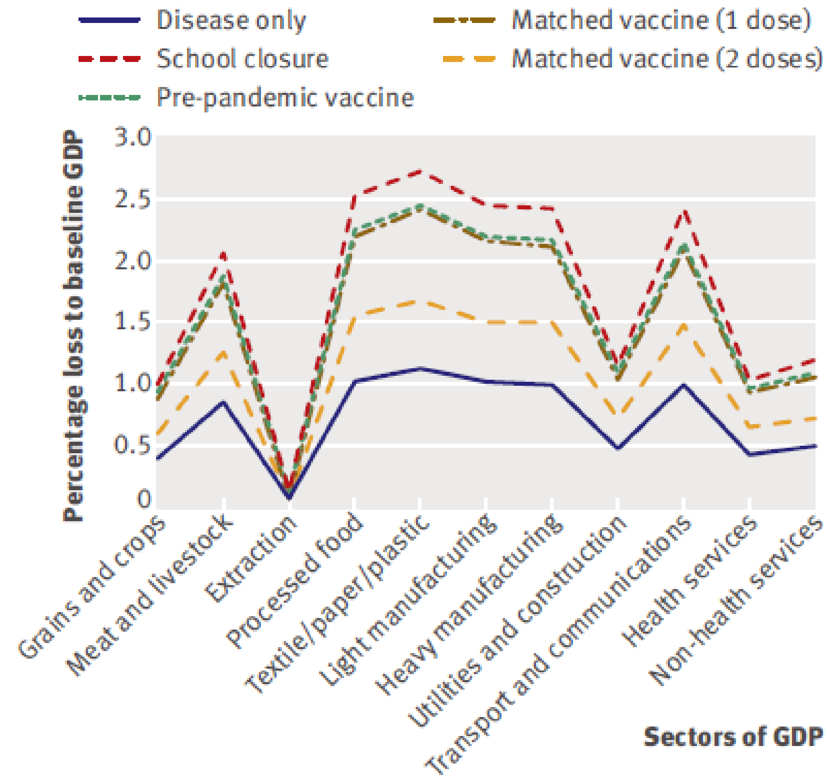


Fig 2 | Impact of pandemic influenza on different economic sectors of UK gross domestic product (GDP)

Smith RD et al. *BMJ* 2009;339:b4571.

Estimating the economic impact of pandemic influenza: An application of the computable general equilibrium model to the UK

Richard D. Smith [a,*], Marcus R. Keogh-Brown [a], Tony Barnett [a,b]

[a] Department of Global Health and Development, Faculty of Public Health & Policy, London School of Hygiene & Tropical Medicine, 15-17 Tavistock Place, London, WC1H 9SH, United Kingdom
[b] London School of Economics and Political Science, London WC2A 2AE, United Kingdom

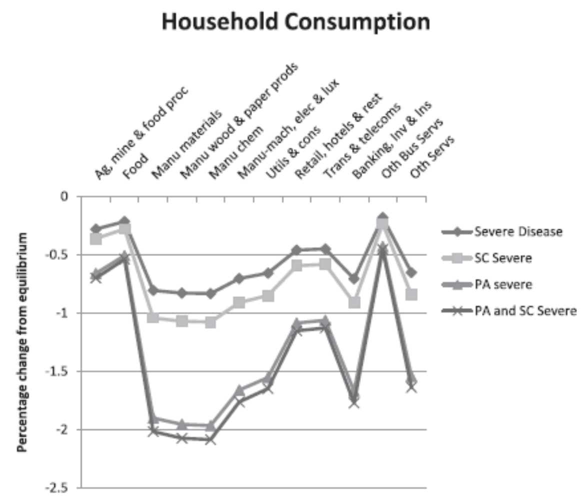


Fig. 3. Household consumption by sector.

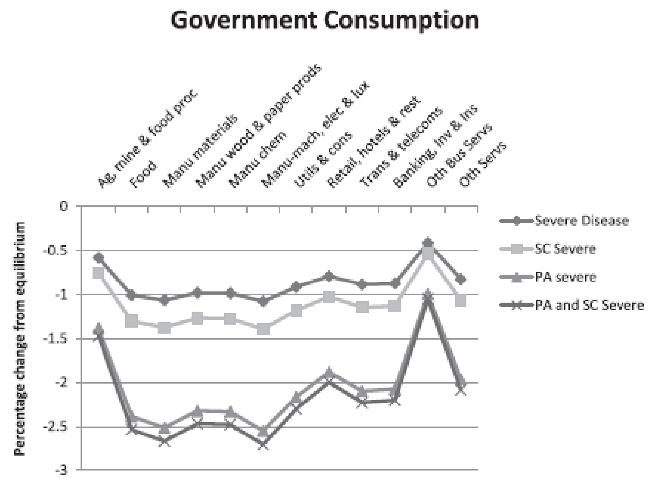


Fig. 7. Government consumption by sector.

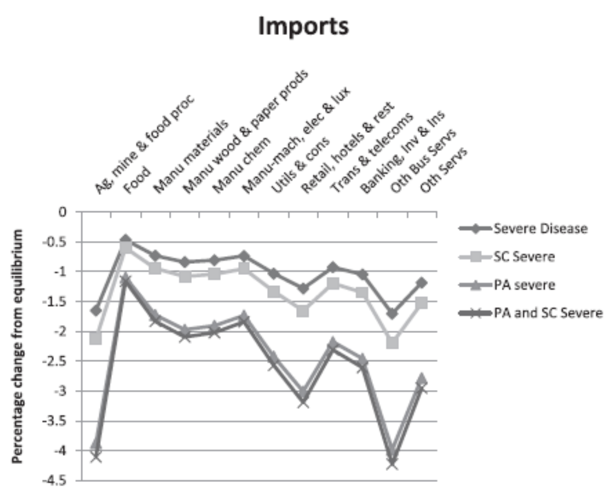


Fig. 5. Imports by sector.

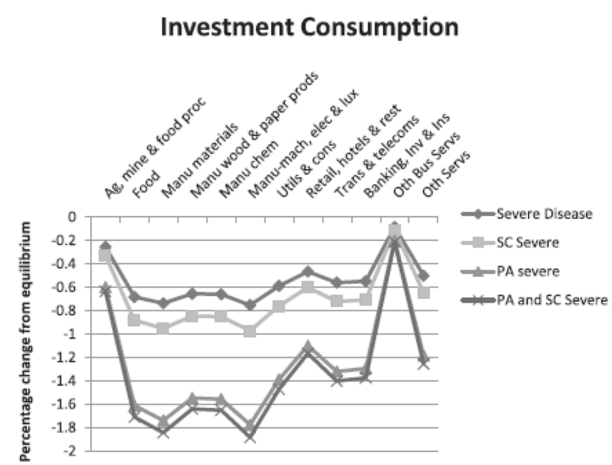


Fig. 6. Investment consumption by sector.

Smith RD et al. *Social Science Med* 2011;73:235-44.

Synthèse

Un modèle d'impact de santé publique peut parfaitement compléter un modèle CE en projetant l'effet d'une intervention sur tout un ensemble de paramètres épidémiologiques et économiques (incidence, prévalence, létalité, hospitalisation, absentéisme, etc.) au niveau populationnel.

Les modèles macroéconomiques permettent de dépasser le cadre médico-économique et épidémiologique de l'évaluation. Ces modèles rendent compte de l'effet d'une intervention sur des grandeurs macroéconomiques (capital humain, recettes fiscales, niveau d'investissement et à terme, le produit intérieur brut).

Ces 2 approches, rapportées à l'investissement nécessaire pour la mise en œuvre de l'intervention considérée, fourniront aux décideurs une évaluation du retour escompté au niveau de la population desservie.

Thank you

Olivier Ethgen
o.ethgen@ulg.ac.be
+32 471 58 30 10