Governance of Preventive Health Intervention and On Time Verification of its Efficiency: the GIOVE study

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Complete List of Authors:	Mennini, Francesco; University of Rome "Tor Vergata", CEIS Sanità - Centre for Health Economics and Management (CHEM) Faculty of Economics Baio, Gianluca; University College London (UK), Department of Epidemiology and Public Health; Bicocca University, Milan, Italy, Department of Statistics Montagano, Giuseppe; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Cauzillo, Gabriella; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Locuratolo, Francesco; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Becce, Gerardo; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Gitto, Lara; University of Rome "Tor Vergata", CEIS Sanità - Centre for Health Economics and Management (CHEM) Faculty of Economics Marcellusi, Andrea; University of Rome "Tor Vergata", CEIS Sanità - Centre for Health Economics and Management (CHEM) Faculty of Economics; University of Rome "La Sapienza", Department of Statistics Zweifel, Peter; Zurich University, Zurich, Switzerland, Capone, Alessandro; Kingston University London, Institute of Leadership and Management in Health (ILMH) Favato, Giampiero; Kingston University London, Institute of Leadership and Management in Health (ILMH)
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Governance of Preventive Health **I**ntervention and **O**n Time **V**erification of its **E**fficiency: the GIOVE study.

F.S. Mennini[1], G. Baio[2], G. Montagano[3], G. Cauzillo[3], F. Locuratolo[3], G. Becce[3], L. Gitto[1], A. Marcellusi[1], P. Zweifel[4], A. Capone[5], G. Favato[5]

[1] CEIS Sanità (CHEM - Centre for Health Economics and Management) - Faculty of Economics, Tor Vergata University, Rome, Italy and Kingston University London, Kingston-upon-Thames, UK
[2] Department of Epidemiology and Public Health, University College London (UK), and Department of Statistics, Bicocca University, Milan, Italy
[3] Department of Health, Safety and Social Solidarity, Personal Services and the Community, Region Basilicata, Italy
[4] Zurich University, Zurich, Switzerland
[5] Institute of Leadership and Management in Health (ILMH), Kingston University London

E-mails:

F.S. Mennini = f.mennini@uniroma2.it
G. Baio = gianluca@stats.ucl.ac.uk
G. Montagano = giuseppe.montagano@regione.basilicata.it
G. Cauzillo = gabriella.cauzillo@regione.basilicata.it
F. Locuratolo = francesco.locuratolo@regione.basilicata.it
G. Becce = gerardo.becce@regione.basilicata.it
L. Gitto = Gitto@CEIS.uniroma2.it
A. Marcellusi = andrea.marcellusi@uniroma2.it
P. Zweifel = peter.zweifel@soi.uzh.ch
A. Capone = atpuzzle@tin.it
G. Favato = G.Favato@kingston.ac.uk

Corresponding author:

Prof. Francesco Saverio Mennini

CEIS Sanità – Centre for Health Economics and Management (CHEM)

Faculty of Economics – University of Rome "Tor Vergata"

Via Columbia, 2

00133 Rome – Italy

Tel: +39 06 72595642

Pers Ph.: +39 333 4991647

Fax: +39 06 233 245 53

E-Mail: *f.mennini@uniroma2.it*

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Francesco Saverio Mennini: substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data

Gianluca Baio: drafting the article or revising it critically for important intellectual content

Giuseppe Montagano: final approval of the version to be published

Gabriella Cauzillo: final approval of the version to be published

Francesco Locuratolo: final approval of the version to be published,

Gerardo Becce: final approval of the version to be published

Lara Gitto: substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data

Andrea Marcellusi: substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data

Peter Zweifel: drafting the article or revising it critically for important intellectual content

Alessandro Capone substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data

Giampiero Favato drafting the article or revising it critically for important intellectual content

CONFLICT OF INTEREST

The authors declare that no conflicts of interest exist.

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Article Summary

1. **Article Focus**

- At present, screening and immunisation are cost-effective strategies to reduce the death-toll of cervical HPV-related malignancies, which in Italy alone amounts to 1,200 women per year.
- While there are no evidences to reduce the coverage of screening in favour of a wider coverage of immunisation, the adoption of a multi-cohort strategy of vaccination would allow a larger proportion of the female population aged between 12 and 25 to be immunised in a shorter period of time (6–8 years).
- A bound optimisation model was developed to determine the allocative efficiency of the resources used for the screening and the vaccination programmes. Subsequently, an observational, retrospective study was carried out to verify the degree of allocation efficiency actually attained after implementation of the multi-cohort immunisation programme.

2. **Key Messages**

- Using a vaccine price of €100 per dose, a coverage rate of 59.6% was required for the most effective allocation of resources. A sensitivity analysis showed that when the price was reduced to €85 per dose, the most efficient coverage rate increased to 69.5%. A vaccination coverage rate of 72.8 ± 2.0% was observed.
- Although statistically significant, the observed inefficiency was progressively reducing from 21% in the July 2007-August 2008 period to 5% after September 2008, when the vaccine price was reduced to €85 per dose.
- The bound optimisation model demonstrated to be a useful approach to assess the allocative efficiency of the resources budgeted to the implementation of a multi-cohort, quadrivalent anti-HPV vaccination programme.

3. **Strengths and Limitations of this study**

- The relevance of this study is enhanced by its internal validity: the sample size was significant (over 12,000 girls enrolled) and coherent (all subjects enrolled were coming from the same Region); the observation time allowed to cover the entire immunization cycle; individual data related to vaccination (including all costs incurred) were complete and accurate (provided by the Regional Health Authority); the bound optimisation model adequately described the available competing choices: immunisation v. screening.
- The bound optimisation model is subject to the condition that the programmes evaluated are completely divisible, with constant return to scale and that every subject included receives a fraction of the total expected benefit. Nonetheless, these limitations do not seem to affect the generalisability of the research outcomes.

ABSTRACT

Background: The GIOVE study was aimed to the achievement of allocative efficiency of the budget allocated to anti-HPV prevention in Basilicata, a Region in the South of Italy. An ex-ante determination of the most efficient allocation of resources between screening and multi-cohort quadrivalent immunisation programmes was followed by the ex-post assessment of the allocative efficiency actually achieved after a 12-month period of implementation.

Methods: A bound optimisation model was developed to determine the allocative efficiency of the resources used by the Basilicata Region for the screening and the vaccination programmes. A sensitivity analysis was carried out to assess the uncertainty associated with the cost of the vaccine. Subsequently, an observational, retrospective study was carried out to verify the degree of allocation efficiency actually attained after implementation of the multicohort immunisation programme. The study enrolled 12,848 girls aged 12, 15,18 or 25 years with a complete recorded vaccination history. The observation period began in July 2007 and continued for 18 months, to ensure full compliance with the recommended schedule of vaccination (0, 2, 6 months) within a 12-month time horizon.

Results: Using a price for the vaccine of €100 per dose, a vaccination coverage rate of 59.6% was required for the most effective allocation of resources. When the price was reduced to €85 per dose, the most efficient coverage rate increased to 69.5%. A vaccination coverage rate of 72.8 ± 2.0% was observed in the Basilicata region,

Conclusions: Although statistically significant ($p<0.001$), the observed inefficiency was progressively reducing from 21% in the July 2007-August 2008 period to 5% after September 2008, when the vaccine price was reduced to €85 per dose. The bound optimisation model demonstrated to be a useful approach to the assessment of the resources allocated to the implementation of a multi-cohort, quadrivalent anti-HPV vaccination programme.

INTRODUCTION

HPV-induced malignancies represent the second most common type of cancer in women worldwide [1]. In Italy, more than 3,000–3,500 new cases of cervical cancer (which corresponds to an age-standardised rate of incidence of between 7.7 and 8.1 cases per 100,000 women) are diagnosed annually [2, 3], and approximately 1,200 women die from this disease every year [2]. Overall, the economic burden to the Italian National Health Service (NHS) that is caused by cervical HPV-related pathologies is considerable, with the cost estimated to lie in the range Euro (€) 200–250 million per year [4, 5].

A programme of screening for cervical cancer has been implemented in Italy since 1996, to reduce the incidence of cervical cancer and its associated mortality rate. Women aged between 25 and 64 are invited for screening for cervical cancer every 3 years, with the aim of achieving the early detection and treatment of precancerous cervical lesions (CIN - cervical intraepithelial neoplasia), and preventing the onset of invasive cervical cancer [6].

In early 2007, a new tool became available to reduce the incidence of HPV-related malignancies: the vaccine, in its bivalent and quadrivalent form. The cost-effectiveness of immunisation against HPV had been previously demonstrated by a large number of modelling studies [7-13]. In one such study that was carried out in Italy, the authors assessed the cost-effectiveness of a programme of quadrivalent vaccination for a single cohort of 12-year-old girls [14]. In their model, the current programme of screening (including the management of HPV-related pathologies) was considered as a comparative case. The results of their study suggested that the introduction of a programme of vaccination using a quadrivalent HPV vaccine alongside the current programme of screening for cervical cancer in Italy would produce an incremental cost-effectiveness ratio (ICER) of €12,303 per life year gained (LYG) and €9,569 per quality-adjusted life year (QALY) gained. An economic assessment of the bivalent vaccine reported a cost of €26,361 per QALY gained [15], which provided further evidence that vaccination against HPV is currently significantly below the threshold value of €30,000–45,000 that is used commonly to determine 'value for money' in health interventions [16, 17].

More favourable economic results were obtained using predictive models that were based on a quadrivalent multi-cohort strategy of vaccination (3–4 cohorts) [18]. When a multi-cohort strategy of vaccination is adopted, a larger proportion of the female population aged between 12 and 25 can be vaccinated in a shorter period of time (6–8 years) and an early reduction of costs can be expected. A multi-cohort programme of vaccination using the quadrivalent vaccine was associated with a total saving of approximately €132 million, as a result of a reduction in the numbers of low-grade and high-grade cervical lesions, anogenital warts, and invasive cervical cancers (Table I) [19].

In July 2007, a decree issued by the State-Regions Conference granted access to quadrivalent vaccination against HPV, which should mandatorily be both free of charge and promoted actively, at least in the cohort of girls aged 12 years, with the progressive achievement of a rate of coverage of 95% in the next five years. The decree was resolving the uncertainty related to the choice of the vaccine (quadrivalent) and the priority of cohort to be immunised (12 year old girls), but the actual modalities of implementation of the immunisation campaign were delegated to individual Regions, under the constraint that the incremental cost of the anti-HPV vaccination would be funded within a budget previously allocated to health care. In order to maximise the net benefits or utilities to public health that can be derived from a proposed decision it is essential to allocate resources as efficiently as possible, in full compliance with the universal principles of equity of access to treatment [20].

The policy makers of the Basilicata Region, in the South of Italy, became concerned about the potential issues of equality and allocative efficiency of resources raised by the choices at hand.

A downsize of the current screening programme could potentially increase the risk of HPV-related malignancies, in the light of the lack of information about the impact of immunisation on the coverage and frequency of screening. In time, women vaccinated in the multi-cohort immunisation programme would enter the age group 25–64 years and thus should still be considered eligible for screening. The option to reduce the resources dedicated to screening would therefore be unethical and, ultimately, it would be likely to have an adverse effect on the women's welfare.

On the other hand, the implementation of a quadrivalent multi-cohort strategy of vaccination in the Region could provide clinical and economic benefits 5–8 years earlier than would be expected with the 12 year old single-cohort strategy made mandatory by the national guidelines. It should be considered, though, that the validity of cost-effective studies is strongly dependent on the accuracy of complex models, based on hundreds of assumptions often derived by sparse sources. In spite of the prescriptive nature of health economic outcomes, they cannot completely resolve the uncertainty at the time of the investment decision, determined by the lack of information on population-wide efficacy of the anti-HPV vaccine in the long term. Moreover, a multi-cohort vaccination strategy would increase the complexity of the immunisation programme, whose rate of implementation represents an unknown variable itself in the simpler one-cohort model.

The objective of this study was to support the health care management of the Basilicata Region to achieve the allocative efficiency of the allowable budget assigned to anti-HPV screening and quadrivalent immunisation programmes. In general terms, the allocative efficiency of a budget between two health care programmes is reached when the population welfare is maximised [21]. As this particular budget was earmarked to prevent HPV-related malignancies, its allocative efficiency would be reached when the number of HPV-related events is minimised given three additional conditions: no change in the frequency and coverage of the current screening programme; a multi-cohort modality of implementation of the new immunisation programme and the achievement of the target coverage required by the national guidelines for the cohort of 12 year old girls. A further condition required by allocative efficiency is that the allowable budget is entirely spent. To date, no studies have examined specifically the level of allocative efficiency of resources assigned to programmes of vaccination against HPV. In order to provide quantitative guidelines relevant to managerial decision, the main objective of the study was further divided into two complementary outcomes:

1. objective *ex-ante*: the determination of the most efficient allocation of resources between the screening and the multi-cohort quadrivalent immunisation programme, given the constraints discussed above;
2. objective *ex-post*: the assessment of the allocative efficiency actually achieved by the screening and the quadrivalent immunisation programmes 12-months after the beginning of its implementation (July 2007).

METHODS

***Ex-ante* objective: the determination of the allocative efficiency of the allowable budget between screening and quadrivalent multi-cohort vaccination.**

The bound optimisation model

The bound optimisation model was adopted in view of the fact that budgetary constraints could be taken into account in the allocation of resources among health care programmes. The bound optimisation model was developed by Weinstein and Zeckhauser in 1973 [22] and further modified by Garber and Phelps in 1997 [23]. It allows makers of health policy to maximise the total expected benefits for a given budget. We used an adapted version of this model widely utilized in our previous analyses [24, 25].

The general problem of bound optimization proposed in this study can be described as follows: we wish to choose δ_I to maximise

$$J = \Sigma_{i=1}^{M} \delta_i x_i^1 \qquad \textbf{(1)}$$

$$\text{subject to constraint } \Sigma_{i=1}^{M} \delta_i x_i^2 \leq R \text{ and}$$

$$0 \leq \delta_i \leq 1 \ (i = 1, \ldots, M)$$

In (1), x_i^1 is the consequential expected benefit from every alternative i. δ_i represents, instead, the fraction of every alternative that should be chosen. The constraints points out as the amount of the costs x_i^2 associated to the select alternatives must be smaller or equal to the available general budget R. The optimal values of $\boldsymbol{\delta_i}$ are data from a resolution from the equation of this form:

$$\delta_i^* = \begin{cases} 1 \text{ if } \dfrac{x_i^1}{x_i^2} > \lambda \\ 0 \text{ if } \dfrac{x_i^1}{x_i^2} < \lambda \\ \pi \text{ if } \dfrac{x_i^1}{x_i^2} = \lambda \quad , 0 < \pi < 1 \end{cases} \qquad \textbf{(2)}$$

where λ is defined as the *critical ratio* (that is the optimal proportion for every of the considered alternatives) of the problem of bound optimization.

Formulation of the problem.

In the model that we adapted, x_1 represents screening, x_2 is the combination of vaccination and screening, and the parameter $E_i(i=1,2)$ denotes the expected benefit of each. B is the budget, and λ and μ are the so-called critical values (i.e. the optimal proportions of the alternatives considered). The vaccination coverage rate was considered to be an indicator of the best achievable benefit given the budgetary constraints in Basilicata. The alternatives compared in the study were as follows:

- ✓ The screening programme (x_1) for the early detection of cervical cancer (i.e. secondary prevention). In Italy, organised screening is based on the Pap smear test, which is currently recommended to be carried out every 3 years;
- ✓ The quadrivalent programme of vaccination (x_2) associated with access to screening for cervical cancer for the four cohorts of women eligible to be included in the multi-cohort vaccination programme.

In the present context, the bound optimisation model requires the following data:

- **Cost** of each alternative. Only direct costs were included in the analysis, due to the lack of data on indirect costs associated with the prevention of HPV-related malignancies in Italy. The cost of screening (C_1) includes the cost of outpatient visits and the materials used to perform the Pap smear test. The combined cost of vaccination and screening ($C_1 + C_2$) also includes the cost of the vaccine.
- **Budget** available for the primary and secondary prevention of HPV-related diseases. The screening component was calculated using the 2007/2008 average value budgeted by the Regional Health Service for Pap tests. The budget allocated to the four-cohort strategy of vaccination and to the associated programme of screening in Basilicata was €2.5 million.
- **Size of female population** eligible for vaccination and inclusion (denominator of x_1). All girls in the Basilicata region who were born in 1996, 1993, 1990 or 1983, and who were still alive in July 2007, were taken into account.
- **Expected benefit** of each of the two alternatives (E_i). Using recently published Italian data [14, 18, 19], the annual number of cervical events induced by HPV, as well as the number averted by both the screening and the quadrivalent vaccine (using a three-cohort strategy of vaccination), were estimated. These cases were related to the pertinent female population of 2006 (provided by the Italian National Institute of Statistics - ISTAT [26]). The number of events was assumed to be unaffected by the inclusion of the fourth cohort (women aged 25 years). The proportion of cases of disease and of cases where disease was avoided was assessed for the whole Italian population.

The expected benefit weighted by both demographics and the frequency of disease was calculated using the following formulae:

$$E_1 = 1 - \sum_k \left(\frac{A_k}{P} \times \frac{A_k}{Tot(A_k)} \right) \times 100 \qquad E_2 = 1 - \sum_k \left(\frac{D_k}{P} \times \frac{D_k}{Tot(D_k)} \right) \times 100$$

where A_k and D_k represent the number of women assigned to the two alternative options (screening alone, or vaccination and screening in combination, respectively), P is the female population of Italy on 1 January 2006, and the index k represents the different HPV-related diseases, such as abnormal Pap smears, precancerous cervical lesions (CIN1, CIN2-3), invasive cervical cancer, and anogenital warts. The incidence of HPV-related diseases that would occur with screening alone and with vaccination and screening corresponded to 90.77 and 36.94 per 10,000 women, respectively. The equations represent the weighted expected benefit of screening alone (E_1) and of vaccination and screening (E_2), expressed in percentage terms as the difference between the unit (100%) and the incidence of HPV-related diseases associated with each of the two alternative strategies. It is worth noting that screening alone has no effect on the detection of anogenital warts.

***Ex-post* objective: the assessment of the allocative efficiency actually achieved by the screening and the quadrivalent immunisation programmes 12 months after the beginning of its implementation (July 2007).**

An observational and retrospective data collection was designed to assess the allocative efficiency of the two programmes. All girls in the Basilicata region who had a recorded vaccination, and who belonged to one of the four selected cohorts (aged 12, 15, 18, and 25 years in 2007), were considered to be eligible for enrolment. Girls who had an incomplete record of vaccination were excluded. The collection of data began in July 2007 and continued for 18 months to ensure full compliance with the recommended schedule of vaccination (0, 2, 6 months) within a 12-month time horizon.

Sources of Data

Data on rates of screening and vaccination, allocation of budgets, and costs (including the total spent on prevention) were obtained directly from each of the five participating Local Healthcare Authorities (LHAs[1]), all of which fall within the remit of the region. The data were related to the period from January 2007 to December 2008. The cost of a full course of quadrivalent vaccination (three doses) was €315, including the costs of administering the vaccine.

The regional demographic archive provided information on subjects' date of birth, sex, and healthcare identification number, whereas data on the course of vaccination (including the patients' names and healthcare identification numbers, together with dates of issue, brand names, and batch numbers of the vaccine) were obtained from the regional vaccination register. All personal data were replaced with a univocal numerical code, which ensured that both archives were anonymous at source (in full compliance with the Italian Privacy Law - Decree 196, 30/06/2003). The observational and retrospective design of this data collection did not necessitate the collection of informed consent from the subjects.

Statistical Analysis

Differences among groups were tested using one-way analysis of variance (ANOVA) for continuous variables, while Pearson's χ^2 test was used for categorical variables. All the tests were two-tailed, and p-values that were less than 0.05 were considered to be statistically significant. Sensitivity analyses were performed to assess the uncertainties associated with the estimates of allocative efficiency. Specifically, we varied the cost of the quadrivalent vaccine by reducing it by 15 percent twice, and both increased and reduced the budget by 10 percent. This is because changes of such an order of magnitude are fairly likely to occur. The bound optimisation model and the

[1] The Local Health Authority is a body delegated by the Italian National Health Service to deliver local healthcare services, commonly at provincial level.

sensitivity analyses were carried out using Mathematica, Version 6.0, and the statistical analyses were performed using SPSS for Windows, Version 16 (Chicago, IL, USA, 2002).

RESULTS AND DISCUSSION

The mean weighted benefit of the combined prevention strategy (vaccination and screening) resulted significantly higher than that of screening alone (91% versus 37% of cervical HPV-related events averted, respectively). For a vaccine cost of €100 per dose, the results show that the vaccination coverage rate should have reached a level of 59.6% to achieve an efficient allocation of resources. The decision makers of the Basilicata Region consequently set a target rate of coverage of 60% for the quadrivalent multi-cohort immunisation programme.

Twelve months after the beginning of the immunisation programme, the actual rate of coverage reached 72.8 ± 2.0%.. This figure is 21% higher than the regional public health target with a difference that was statistically significant ($p<0.001$).

The highest vaccination coverage rate was reported in the cohort of girls aged 12 years (84.7% ± 2.0%). However, it should be noted that similar values were recorded in the two chronologically subsequent cohorts (15 and 18 years) with rates of 79.9% ± 4.3% and 78.1% ± 3.4% for girls aged 15 and 18 years, respectively. In contrast, a statistically significantly lower coverage rate (52.1% ± 3.1%) was observed in the cohort of women aged 25 years. This rate was not only significantly below the average value of 72.8% ($p<0.0001$), but was also significantly less than the value required to achieve the allocative efficiency predicted by the bound optimisation model ($p<0.001$).

A basic sensitivity analysis performed on the bound optimization model shows that in the Basilicata Region, the optimal rate of coverage was exceeded when the multi-cohort strategy of vaccination against HPV was used, achieving an actual inefficient allocation of resources between screening and vaccination, in favor of the second. However, if the price of the vaccine were to be reduced to €85 per dose, the optimal rate of vaccination coverage would increase to 69.5% (see point γ in Figure 1). As a matter of fact, in September 2008, the price paid for the quadrivalent vaccine by the Basilicata region dropped to €85 per dose.

Figure 1 shows the general case where, by using an optimisation procedure, the authorities in Basilicata could maintain the current high rate of coverage with a reduced budget (equivalent to a reduction in the cost of the vaccine from €85, point α, to €72.5 per dose, point β). Alternatively, the rate of coverage could be reduced to the optimal value of 69%, thereby achieving the concomitant savings (point γ).

Further reductions in price, as reflected in the progression towards point δ, should provide scope for savings that can be represented by the shaded area ($\alpha\gamma\delta$). In this way, regional decision makers could authorise the reallocation of resources to other programmes of prevention, while maintaining the expected high level of allocative efficiency of the budget allocated to the prevention of HPV-related pathologies.

Regional authorities might also decide to reduce the allocated budget by 10%. In such scenario, although the intercept is still within the boundary of the allocative efficiency curve in Figure 1, an immediate mean decrease of vaccination coverage rate of 10.1% ± 0.9% would be observed. This would have the knock-on effect of reducing some of the expected benefits.

Our findings for the 12-month period of our study demonstrate that the Basilicata Region was able to leverage the reduction in the price of the vaccine from €100 to €85 per vial to achieve an higher than planned coverage rate (73% vs. 60%), progressively reducing the inefficiency of the actual resource allocation to the quadrivalent multi-cohort vaccination from 21% in the period July 2007-August 2008 to an almost negligible 5% after September 2008, when the price reduction came into effect. In the context of the Italian national programme of vaccination, the Basilicata region is in full compliance with the guidelines established by the Italian State-Regions Conference, which in turn were determined in accordance with both the Ministry of Health and the National Institute of Health. Moreover, the implementation of a multi-cohort strategy of vaccination in the region should provide clinical and economic benefits 6–8 years earlier than would be expected with a single-cohort strategy. Figure 2 provides an explanation of the benefits associated with the multi-cohort programme. Our findings are consistent with those of a modeling study published in 2008 [18], which demonstrated that the greater flexibility in the rate of coverage that results from vaccinating between three and four cohorts rather than one (in the range 63.0–72.0% for a four-cohort strategy compared with a range of 78.0–83.5% for a two-cohort strategy) enables a higher efficiency of vaccination to be maintained [19].

The present study does have some limitations. The bound optimisation model is subject to the condition that the programmes evaluated are completely divisible, with constant return to scale and that every subject included receives a fraction of the total expected benefit. Concerning the first condition, although we cannot assume that health care programmes are completely divisible, we can assume that there are sufficiently many interventions that each one is small in value compared to the whole: thus, the expected value is approximately a continuum [22]. The return to scale of anti-HPV immunisation is unlikely to be constant due to the effect of herd immunity [27], although at present no epidemiologic data are available to confirm a non-linear relationship between coverage and expected reduction of events. We can still assume that the return to scale of the anti-HPV immunisation is constant within the ranges taken into consideration to determine the allocative efficiency of the allowable budget. Lastly, the third condition is fully respected, since every woman included in the study maintains the access to the screening programme, so she will receive a fraction of the expected benefit.

CONCLUSIONS

The use of the Bound Optimisation Model was found to be a very useful and rational approach to the short-term assessment of the governance of resources allocated by the Basilicata region to the implementation of a multi-cohort programme of quadrivalent vaccination against HPV. However, the model does not resolve all the issues related to the cost-effectiveness of such programmes of vaccination. Therefore, further probabilistic models or observational studies using measured outcomes are required. These should be designed specifically to minimise the uncertainties associated with the large number of variables that need to be considered in such a complex problem.

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TABLES

Table I - Projected outcomes averted by means of the quadrivalent vaccine and expected reductions in expenditure

Outcomes	Annual expected number of events	Number of events prevented with the quadrivalent vaccine	Reduction in expenditure (€ million)
Abnormal pap smears	415,000	258,337	3.8
Colposcopies	116,000	76,909	19.2
LSIL[‡] & ASCUS[§]	91,000	56,648	22.7
HSIL[†]	13,700	9,097	8.2
Cervical cancer	4,000	2,988	49.9
Genital warts	125,000	115,625	27.8
TOTAL	764,700	519,604	131.6

In this multi-cohort model, a vaccination coverage rate of 80% was assumed [25, 26]. Reductions were calculated at the peak efficiency of the vaccination programme. A cross-protection effect of the quadrivalent vaccine was also considered. [‡] LSIL - Low-grade Squamous Intraepithelial Lesion; [§]ASCUS - Atypical Squamous Cells of Undetermined Significance; [†] HSIL - High-grade Squamous Intraepithelial Lesions

Table II – Data on vaccination rates provided by the Basilicata region and included in the Bound Optimisation Model

	Cohort 1996	Cohort 1993	Cohort 1990	Cohort 1983	All Cohorts
Girls eligible for vaccination	2,785	3,064	3,426	3,573	12,848
Vaccinated in LHA 1	414	456	519	272	1,661
Vaccinated in LHA 2	825	857	873	739	3,294
Vaccinated in LHA 3	278	295	361	234	1,168
Vaccinated in LHA 4	502	470	579	370	1,921
Vaccinated in LHA 5	341	371	344	249	1,305
Total vaccinated	2,360	2,449	2,676	1,864	9,349
Vaccination coverage rate (%)	84.7	79.9	78.1	52.2	72.8
SD (%)	*2.0*	*4.3*	*3.4*	*3.1*	*2.0*

Note: Differences in vaccination coverage rates were statistically significant between cohorts ($p<0.0001$).

Overall, the vaccination coverage rate reached 72.8 ± 2.0% after 12 months. The highest vaccination coverage rate was reported in the cohort of girls aged 12 years (84.7% ± 2.0%). However, it should be noted that similar values were recorded in the two chronologically subsequent cohorts (15 and 18 years) with rates of 79.9% ± 4.3% and 78.1% ± 3.4% for girls aged 15 and 18 years, respectively. In contrast, a statistically significantly lower coverage rate (52.1% ± 3.1%) was observed in the cohort of women aged 25 years. This rate was not only significantly below the average value of 72.8% ($p<0.0001$), but was also significantly less than the value required to achieve the allocative efficiency predicted by the bound optimisation model ($p<0.001$).

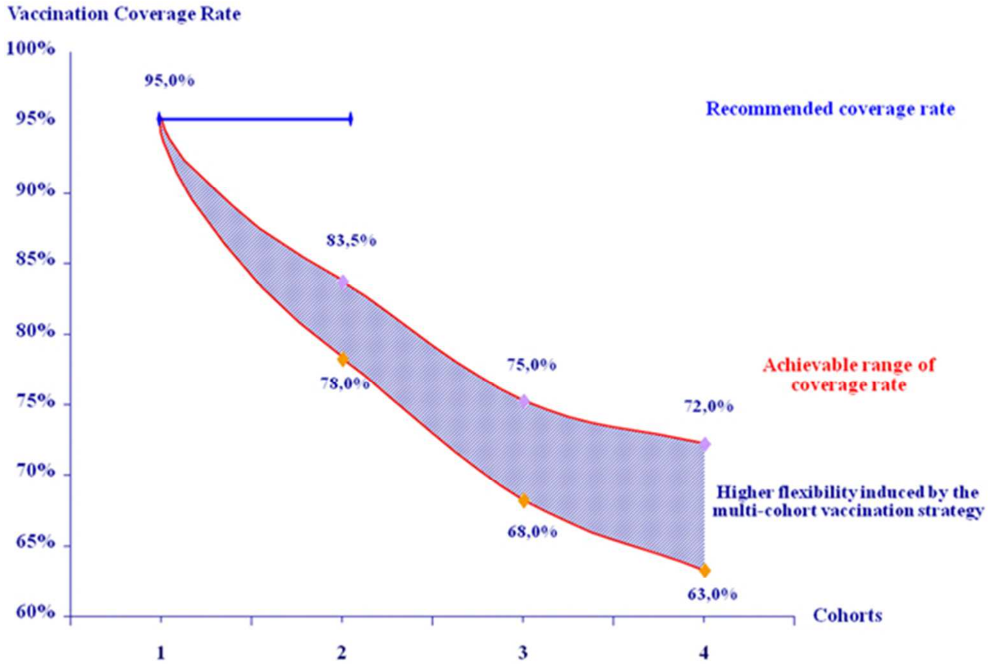
FIGURE

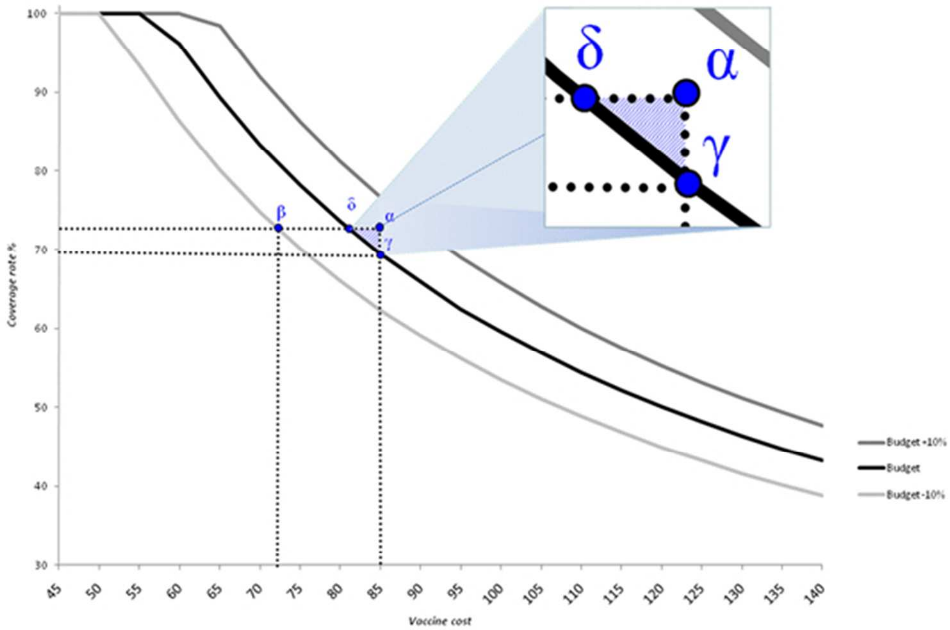
Figure 1 - Sensitivity analysis of allocative efficiency performed on the basis of variations in budget and cost of vaccine

Figure 1 shows the general case where, by using an optimisation procedure, the authorities in Basilicata could maintain the current high rate of coverage with a reduced budget (equivalent to a reduction in the cost of the vaccine from €85, point α, to €72.5 per dose, point β). Alternatively, the rate of coverage could be reduced to the optimal value of 69%, thereby achieving the concomitant savings (point γ).

Further reductions in price, as reflected in the progression towards point δ, should provide scope for savings that can be represented by the shaded area (αγδ. In this way, regional decision makers could authorise the reallocation of resources to other programmes of prevention, while maintaining the expected high level of efficiency of the planned programme of vaccination against HPV.
Regional authorities might also decide to reduce the allocated budget by 10%. In such scenario, although the intercept is still within the boundary of the allocative efficiency curve in Figure 2, an immediate mean decrease of vaccination coverage rate of 10.1% ± 0.9% would be observed. This would have the knock-on effect of reducing some of the clinical benefits.

Figure 2 - Relationship between coverage rate and number of cohorts vaccinated [19]


Vaccination Coverage Rate
100%
95%
90%
85%
80%
75%
70%
65%
60%
95,0%
83,5%
78,0%
75,0%
68,0%
72,0%
63,0%
Recommended coverage rate
Achievable range of coverage rate
Higher flexibility induced by the multi-cohort vaccination strategy
Cohorts
1
2
3
4


Coverage rate %
Vaccine cost
Budget +10%
Budget
Budget -10%
β
δ
α
γ

Governance of Preventive Health Intervention and On Time Verification of its Efficiency: the GIOVE study

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Complete List of Authors:	Mennini, Francesco; University of Rome "Tor Vergata", CEIS Sanità - Centre for Health Economics and Management (CHEM) Faculty of Economics Baio, Gianluca; University College London (UK), Department of Epidemiology and Public Health; Bicocca University, Milan, Italy, Department of Statistics Montagano, Giuseppe; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Cauzillo, Gabriella; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Locuratolo, Francesco; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Becce, Gerardo; Region Basilicata, Italy, Department of Health, Safety and Social Solidarity, Personal Services and the Community Gitto, Lara; University of Rome "Tor Vergata", CEIS Sanità - Centre for Health Economics and Management (CHEM) Faculty of Economics Marcellusi, Andrea; University of Rome "Tor Vergata", CEIS Sanità - Centre for Health Economics and Management (CHEM) Faculty of Economics; University of Rome "La Sapienza", Department of Statistics Zweifel, Peter; Zurich University, Zurich, Switzerland, Capone, Alessandro; Kingston University London, Institute of Leadership and Management in Health (ILMH) Favato, Giampiero; Kingston University London, Institute of Leadership and Management in Health (ILMH)

Primary Subject Heading:	Health economics
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Keywords:	HPV vaccination programmes, bound optimisation model, allocative efficiency, vaccination coverage rate, quadrivalent vaccine, Basilicata Region

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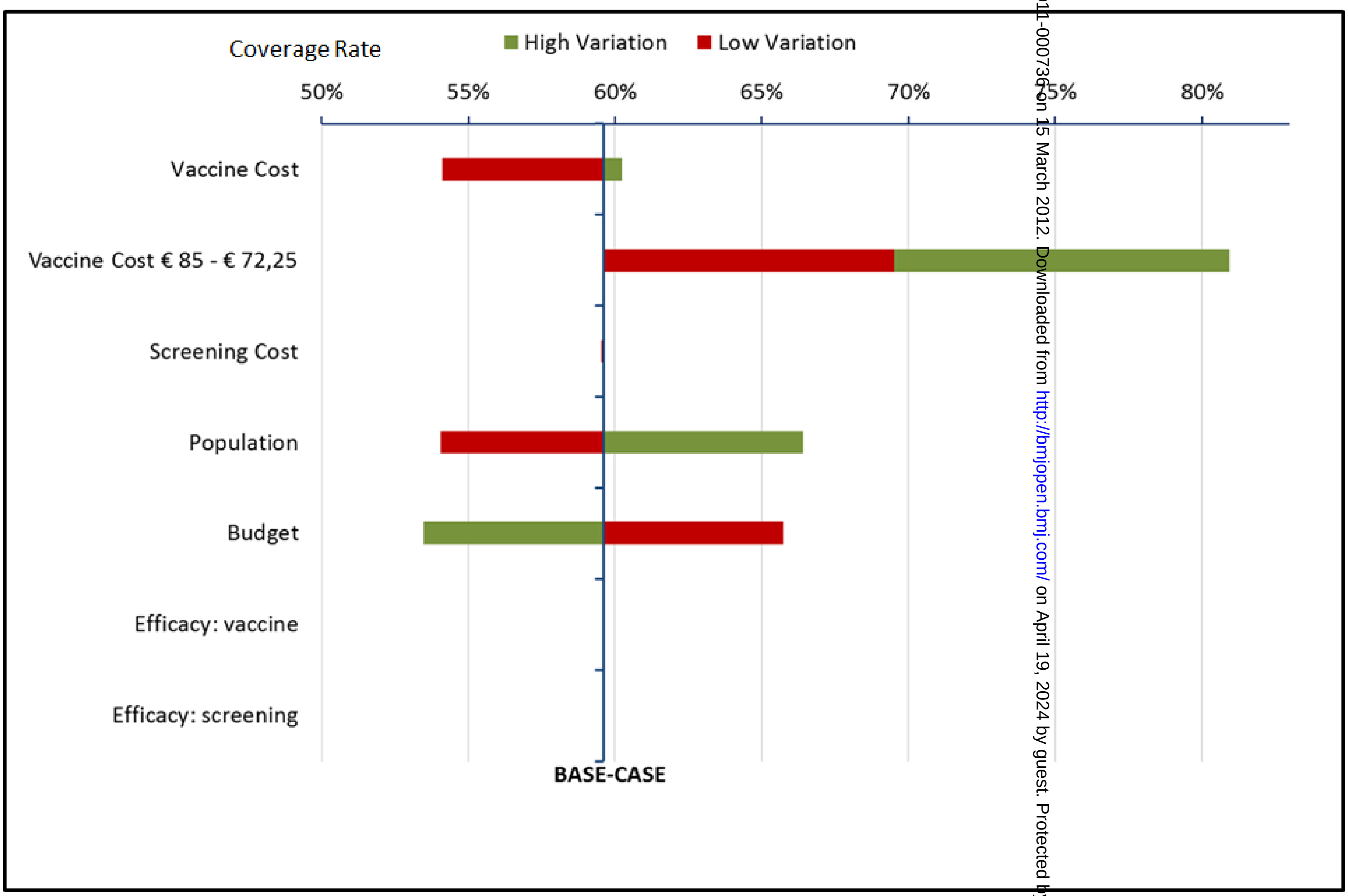
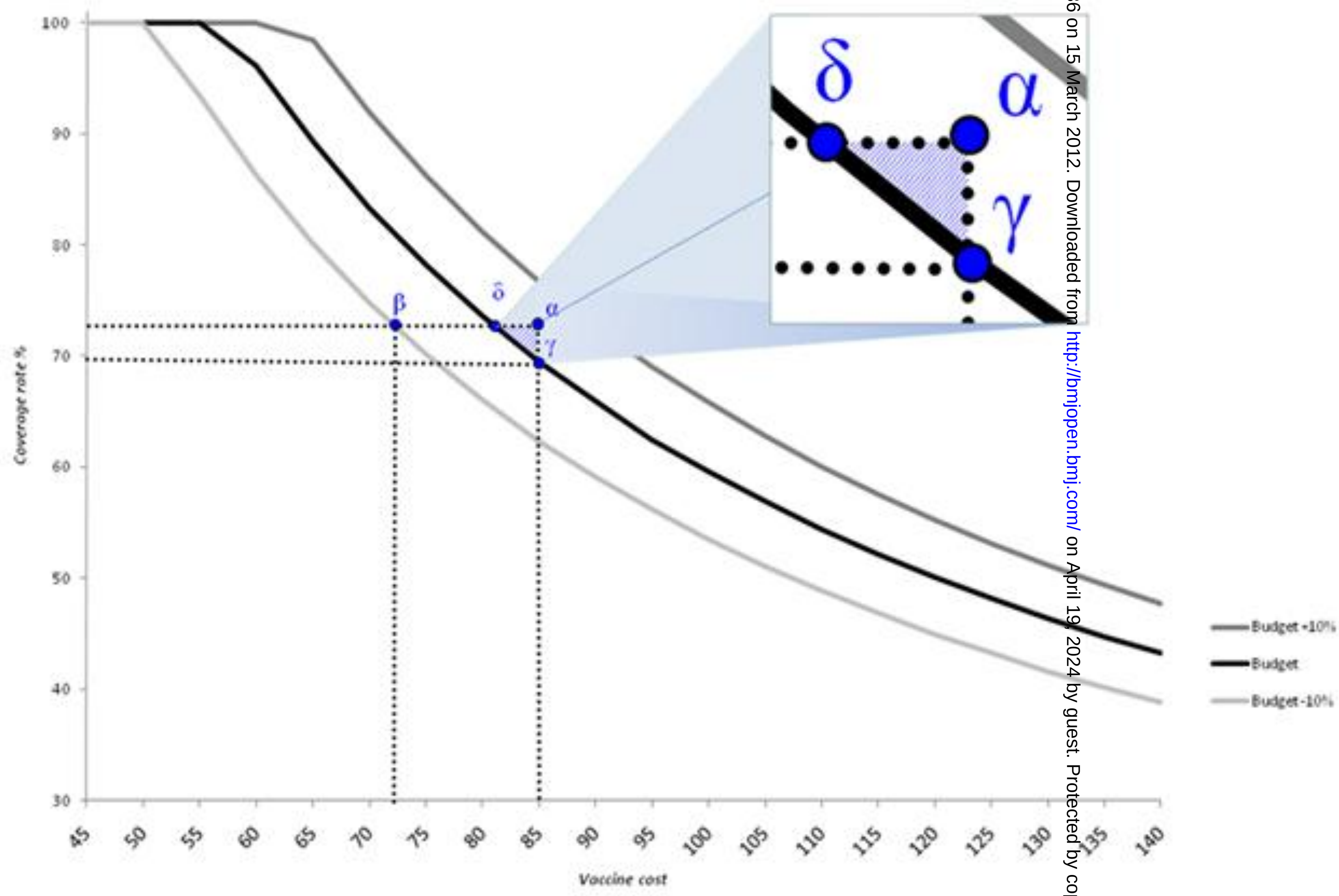

Coverage Rate
High Variation
Low Variation
50%
55%
60%
65%
70%
75%
80%
Vaccine Cost
Vaccine Cost € 85 - € 72,25
Screening Cost
Population
Budget
Efficacy: vaccine
Efficacy: screening
BASE-CASE


δ
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Coverage rate %
Vaccine cost
100
90
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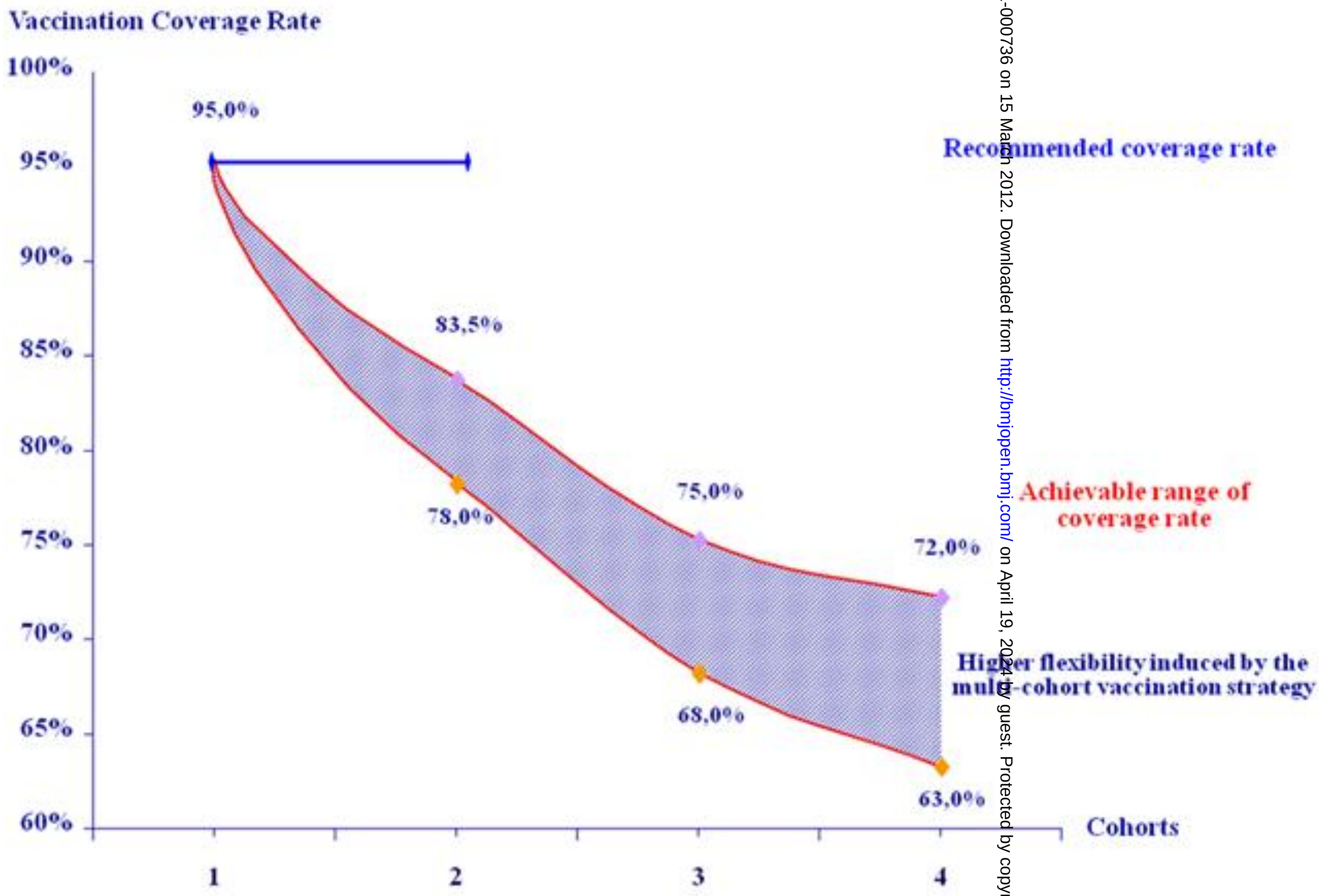
Budget +10%
Budget
Budget -10%


Vaccination Coverage Rate
100%
95%
90%
85%
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95,0%
83,5%
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75,0%
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Recommended coverage rate
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