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Management of Pneumococcal Disease and Economic Implications: a Budget Impact Analysis

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Abstract

Pneumococcal pneumonia has a high clinical burden in terms of morbidity, mortality and hospitalization rate, with heavy implications for worldwide health systems. The socio-economic impact of diseases caused by Streptococcus pneumoniae is very important. The aim of the study was to demonstrate the potential economic advantages with the implementation of an active anti-pneumococcal 13-valent vaccine strategy in Campania region (Southern Italy) in two different categories of subjects: adults (aged 50-79) and adults (50-64) +65 at risk (hypertension, nephropathies and heart diseases). Vaccination costs were compared to costs necessary to treat avoidable diseases in the presence and absence of a vaccination program. In particular, a Budget Impact Analysis (BIA) was applied in two different work hypotheses. Offering anti-pneumococcal 13-valent vaccine to the adult population (50-79) was quantified a saving 29 million euros for Italian national health service in five years. Offering anti-pneumococcal vaccine to adults at risk would generate a return of around 10 million euros. This study showed that both hypothesized immunization strategies could produce savings.

JEL classification numbers: M15, M21, J58.
Keywords: Management disease, budget impact analysis, economic implications.

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1. Introduction

Pneumococcus is a known cause of meningitis, pneumonia, sepsis, and acute otitis media in children and adults globally. In Italy, there is a significant number of persons suffering of pneumococcal pneumonia. Persons aged 50-60 years or older, immunocompromised patients, patients with co-morbidities, such as chronic obstructive lung disease and congestive heart failure, are at the highest risk for developing pneumococcal pneumonia. The treatment costs of such inpatients and outpatients are very high. In Italy, immunization of persons at risk to develop the diseases caused by Streptococcus pneumoniae is carried out using a pneumococcus polysaccharide vaccine according to clinical indications (1-4).

Pneumococcal vaccination is extensively recommended for subjects aged ≥65 years and for those aged 50-64 years at high risk (HR) for specific health conditions, such as diabetes, cardiovascular diseases, nephropathies, hypertension and Chronic obstructive pulmonary disease (COPD) (5,6). In Italy, the Ministry of Health recommends the use of conjugated 13-valent vaccine (PCV) for children aged <2 years, while the immunization with 23-valent polysaccharide vaccine (PPV23) is recommended for adults aged ≥65 years and for HR subjects aged ≥2 years (7). However, the levels of immunization coverage among adults are so far insufficient. In fact, clinical studies showed that this formulation is unable to induce an adequate and durable immune response, especially in HR individuals and against non-invasive pneumococcal diseases (8-9).

2. Background

Vaccine and vaccinations are a fundamental right of the citizen and the community and an unavoidable responsibility of decision-makers. The World Health Organization recognizes that vaccines are an essential investment for a country and the world of the future. The protection of the population against serious diseases is a guarantee of better health and allows the individual to fully develop their potential. Further important advantages may derive from the administration of appropriate vaccines in adolescence, adulthood and the elderly. Vaccines have made it possible to eradicate a very serious disease such as smallpox, to reduce the morbidity of polio by 99%, to save millions of years of disability caused by diseases such as diphtheria, tetanus, whooping cough, measles, meningitis, etc. years ever new vaccines have become available, thanks to advances in epidemiology, immunology and molecular biology. Therefore, decision-makers have found themselves and often find themselves having to choose whether to introduce a new vaccine into national vaccination programs. Many people are interested in vaccinations and the introduction of a new vaccine. Again, as with other health technologies, all stakeholders must be involved. The stakeholders are, in general, all citizens; among these, in particular, health professionals and their scientific and professional associations, elected by citizens at different institutional levels for the protection of health, health and socio-health structures, commercial and non-profit partners that provide goods and services, universities, voluntary associations etc (10). The needs

and expectations of stakeholders can be combined in different ways in the whole of the visions: professional, organizational and relational. Thus, when it is desired to introduce a new vaccine, interests can either converge, for example, on the issues of efficacy and safety or diverge, for example, on the issues of costs, organizational structures, etc. Furthermore, the parties perceive and perceive the problems differently according to value or/and concrete priorities. Decision-makers promote consultations with stakeholders to better define immunization strategies.

3. Objective

The aim of the study was to demonstrate the potential economic advantages with the implementation of an active anti-pneumococcal 13-valent vaccine strategy in Campania region (Southern Italy) in two different categories of subjects: adults (aged 50-79) and adults (50-64) +65 at risk (hypertension, nephropathies, COPD, and heart diseases) (11).

4. Methods

Budget impact analyses (BIA) are an essential part of a comprehensive economic assessment of a health care intervention. It is used to assess whether the adoption of a new health technology is affordable, given the resource and budget constraints of the context (12).

BIA data is often examined in conjunction with cost-effectiveness analysis (CEA) data to help inform decisions makers when developing reimbursement policies within the resource constraints of their health care system (13). The literature on this subject remains scarce compared to that on cost-effectiveness/utility analysis. The first work on BIA dates back to articles by Mauskopf (14) and Trueman (15). In recent years, the analytical framework of BIA has developed and its use is now part of the regulatory submission process in several countries for the evaluation of health interventions (16).

In this contest, the Budget Impact Analysis was developed to analyze for a 5-years period the impact of an adult pneumococcal vaccination program in the Campania region. The model considered two cohorts: at first, the group of subjects aged 50-79 (about 1 million of individuals in the region), and later HR individuals aged 50-64, together with all those aged 65 y. HR subjects were considered those with chronic diseases such as diabetes, hypertension, nephropathies and cardiovascular diseases (17).

The analyses were performed on the resident population in Campania on January 1, 2016, as reported by the National Institute for Statistics, without considering sex and origin. On the base of the average national coverage for the last influenza immunization program in Italy in the elderly, vaccination coverage of the targeted cohorts was supposed to be 60%. Community-Acquired Pneumonia (CAP) incidence was considered equal to 3.34‰.

Pneumococcal CAP data in adult population were obtained from the hospital discharge forms of respiratory departments which participate to the regional training

network. During the years 2016-2017, 18,965 CAP cases were registered. Assuming that the overall rate of CAP due to Spn is about 40%, the number of cases per year was estimated to be 3,793.
On the basis of previous studies, the vaccine efficacy against pneumococcal pneumonia was assumed to be 87.5%. Expected cases were corrected for the global mortality rate, as obtained from 2019 National Institute for Statistics data.
The economic model was based on the difference between the costs sustained with (vaccine plus expected cases) and without (only expected cases) a vaccination program.
The cost of the vaccine was 42.5 Euro per dose; the cost of a CAP case was assumed to be the average of costs for complicated and non-complicated pneumonia cases, equal to 3,809 Euro (18,19). Costs were updated to a rate of 3%. To test the strength of results, a sensitivity analysis was applied by considering a +/−10% variation in the vaccine efficacy.

5. Results

Costs needed for the vaccination of the first targeted cohort (HR aged 50-79 y) in 5 y of follow-up are reported in **Table 1**. The costs per year with or without immunization of the first cohort are reported in **Figure 1**; the first scenario includes vaccination costs.

Table 1: Costs (Euro) for the immunization of the first targeted cohort (HR 50-79 y).

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Vaccination costs	25,321,482	483,568	505,692	542,146	570,471	27,423,359

Source Liguori et al. 2014

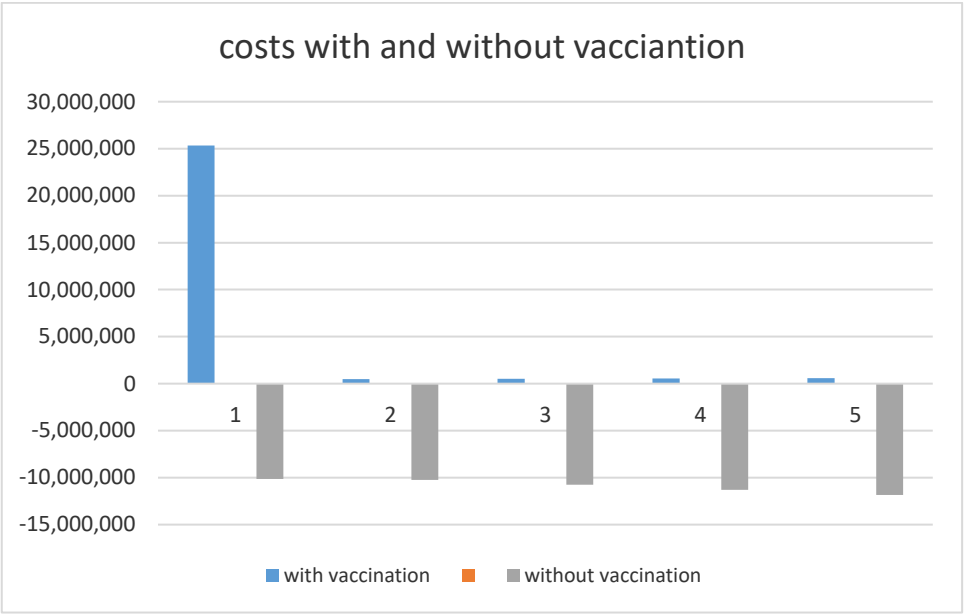

Figure 1: Costs (Euro) with and without vaccination of the first targeted cohort (HR 50-79 y)

During the first year, the implementation of the vaccination program requires more than twofold the resources needed for CAP cases expected without vaccination. However, vaccination costs notably decrease even from the second year.

The cost-effectiveness analysis considered savings and avoided cases achievable in 5 y with vaccination. **Table 2** shows the total costs at the end of 5 y for the two scenarios. The difference between these costs represents the savings achievable at the end of the 5 y.

For the first targeted cohort, total pneumococcal CAP cases expected with a vaccination program were assumed to be 509, while those expected without vaccination were estimated to be 4,083 (with a reduction of 3,574 cases). Therefore, the final savings per CAP case is equal to 8,116 Euro (**Table 2**), what relationship (comparation) between costs and avoided cases.

Table 2: Cost-effectiveness analysis for the first targeted cohort (HR 50-79 y); costs expressed in Euro.

	No vaccination	Vaccination	Difference	Savings/case
Costs	64,467,625	35,461,965	29,005,660	
CAP cases n.	4,083	509	3,574	
				8,116

Source Liguori et al. 2014

The BIA for the base case scenario confirms the great initial expense and the following savings, up to 29,005,660 Euro after 5 years (**Table 3**).

Table 3: Budget impact analysis (BIA) at 5 y for the first targeted cohort (HR 50-79 y) costs and savings expressed in Euro.

Year 1	Year 2	Year 3	Year 4	Year 5	Total
+15,169,851	- 10,241,572	- 10,770,598	- 11,307,841	- 11,855,501	- 29,005,660

Source Liguori et al. 2014

The sensitivity analysis was carried out by varying the effectiveness of the vaccine (+/-10%):
estimated savings after 5 y could be 34,662,134 Euro in the first case, and 23,402,745 in the worst scenario (data not shown).
As for the second targeted group (HR subjects aged 50-64 plus 65-years-old subjects), **Table 4** shows vaccination costs in 5 y. The costs per year with or without immunization of the first cohort are reported in **Figure 2**.

Table 4: Costs (Euro) for the immunization of the second targeted cohort (HR 50-64 y + 65-y-old).

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Vaccination cost	11,173,900	1,725,532	1,996,951	2,400,156	2,454,326	**19,750,864**

Source Liguori et al. 2014

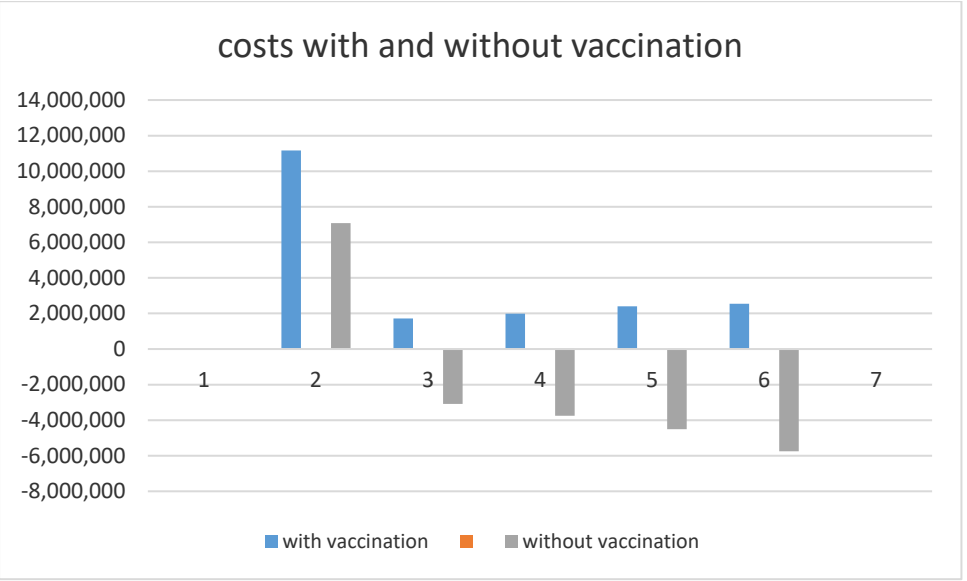

Figure 2: Costs (Euro) with and without vaccination of the second targeted cohort (HR 50-64 y + 65-y-old)

In this case also, at the first year, the costs with vaccination seem to be higher than those for CAP cases in the second scenario; however, even from the second year, it's possible to observe notable savings.

Table 5 reports savings resulting from the difference between the two scenarios. The number of expected cases (2,694) among the second targeted cohort without vaccination could be reduced by vaccination to 337. With this strategy, the final savings per CAP case is equal to 4,245 Euro **(Table 5)**.

Table 5: Cost-effectiveness analysis for the second targeted cohort (HR 50-64 y + 65-y-old); costs expressed in Euro.

	No vaccination	Vaccination	Difference	Savings/case
Costs	34,004,956	23,998,938	10,006,017	
CAP cases n.	2,694	337	2,357	
				4,245

Source Liguori et al. 2014

BIA showed at the end of the follow-up achievable savings equal to 10,006,017 Euro (**Table 6**).

Table 6: Budget impact analysis (BIA) in 5 y for the second targeted cohort (HR 50-64 y + 65-y-old); costs and savings expressed in Euro.

Year 1	Year 2	Year 3	Year 4	Year 5	Total
€ 7.077.606	-€ 3.093.686	-€ 3.748.167	-€ 4.500.496	-€ 5.741.275	**-€ 10.006.017**

Source Liguori et al. 2014

Sensitivity analysis showed savings equal to 10,879,772 Euro when considering a 10% increase in the effectiveness of the vaccine and equal to 9,132,263 Euro with a 10% decrease (data not shown).

6. Discussion

The new paradigm of evidence-based medicine for decision-making has widely grown in recent years, making available to public health care policies - and to professionals and managers as well - tools to assess the clinical and welfare rationality of public choices.

The evidence-based health care approach currently support most of the control activities and decision-makers' choices, thus becoming a real asset in all health care organization levels: national first, and then regional.

This study represents an example of how these indicators could be useful to manage and control diseases with a high burden.

Only by appropriate preventive measures - specific vaccination strategies - the quality of life of patients can be improved and the number of cases can be reduced. In past years, the aspect of the cost-effectiveness of vaccinations has been addressed with "ad hoc" analysis. A strategy is considered efficient only if it is also effective, according to recognized high-level scientific evidence.

7. Conclusion

In conclusion, despite the inherent limitations of this model, the analysis suggests that a 65-year-old cohort vaccination programme with PCV13 in Italy would avoid a large number of cases of pneumococcal disease over a 5-year period and would be a cost-saving measure from a healthcare system perspective.

The economic evaluation of pneumococcal vaccine for adult groups represents an essential instrument to support health policies. In fact, due to the cost restriction, stakeholders should know the value for money of a new immunization strategy, but also its budget impact as in the short as in the long period. As described above, this impact comes from the difference between the cost of vaccination program and

savings achievable through the vaccine-related reduction of cases.

The pharmacoeconomics evaluation carried out in this study showed that both hypothesized immunization strategies could produce savings. However, this strategy requires a high investment in a short period. On the contrary, the second hypothesis implies less initial costs but generates lower savings.

It has to be noted that the present analysis considered only direct costs using the perspective of the National Health Service. Therefore, the conservative nature of this evaluation disregards further implications that could be advantageous for the local health system.

In the health care system, policy-makers' choices basically depend on two elements which are concatenated together. There are the financial resources available; on the other, the epidemiological context of reference that will decree the priorities on the allocation of resources.

In conclusion, results obtained for the base case and from the sensitivity analyses support the vaccination for adults and adults at risk. This strategy could represent a sustainable and savings-producer health policy.

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