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OUTCOME-ORIENTED PREVENTION WITH E-HEALTH SUPPORT – A GAME-THEORETICAL APPROACH

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Abstract: Life expectancy and years spent in good health diverge greatly in Austria. Also, only around 2% of total current public healthcare expenditure was spent on prevention in 2019, compared to 40.5% for inpatient healthcare. This article examines the expected benefits of an overall prevention concept with eHealth support, consisting of primary and secondary prevention, for social insurance and insured persons using game-theoretical modeling. The modeling is carried out in four scenarios.

The results of the game-theoretical model show that the use of eHealth applications can lead to a significant increase in benefits for insured persons despite the associated costs. The number of people practicing prevention and the overall benefit are higher in the two scenarios with eHealth support than in the two without. Although the benefit of social insurance decreases with introducing eHealth due to costs, more people are reached and motivated to engage in prevention. In the long term, however, a certain saturation effect can be observed. It is no longer possible to motivate quite as many people to engage in prevention as in the previous scenario. Concepts for sustainable prevention behavior are therefore needed.

Keywords: Prevention, eHealth, Health Economics, Game Theory

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1 BACKGROUND

Life expectancy and years spent in good health diverge greatly in Austria. At the end of 2021, life expectancy was 83.8 years (women) and 78.8 years (men), while the average number of years spent in good health was only 58 (women) and 57 (men), which is significantly below the European average. [2] So a discussion about prevention is needed, especially as only around 2% of total current public healthcare expenditure was spent on this type of service in 2019, compared to 40.5% for inpatient healthcare. [7] Prevention should be considered holistically in the two dimensions of primary and secondary prevention. The former is the personal responsibility of healthy insured persons (e.g. through exercise and a healthy diet); the latter refers to measures for the early detection, avoidance and early treatment of illness, such as screening programs covered by social insurance. [1] While primary prevention (PP) can certainly lead to cost reductions in the healthcare system at (low) cost for individuals, secondary prevention (SP) often leads to rising costs, even though preventive examinations and screenings can be cost-effective. [6] The use of eHealth has the potential to support the increase in prevention rates, but there is often still a lack of target group-specific and resource-oriented implementation concepts. [3][4]

This article examines the expected benefits of an overall prevention concept with eHealth support, consisting of primary and secondary prevention, for social insurance and insured persons using game-theoretical modeling. This can form the basis for the development of an outcome-oriented incentive system.

2 METHODOLOGY

Holistic prevention based on an incentive system requires at least the involvement of insured persons (related in particular to PP) and social insurance (related in particular to SP). In the following, these two groups are modeled using game theory based on the standard model of a Neumann-Morgenstern function. [5] Aspects of regional differences and individual abilities and health conditions are not considered in this (first) approach.

The modeling is carried out in four scenarios: 1. No SP is available. From the perspective of the social insurance, the optimal level of PP is determined. 2. There is an offer of SP on the part of the social insurance, which can be consumed by the insured persons. Through collaboration, both groups attempt to increase the overall level of prevention. 3. eHealth applications are available, which are associated with higher introductory costs. 4. Support through eHealth will be examined in the longer term in terms of costs, benefits and prevention participants.

Let's assume a Bismarck system in which all citizens are subject to compulsory insurance without free choice of insurer. Let the number of insured persons be N. The social insurance (SI) is not profit-oriented, but it has an interest in optimally allocating the available budget and maintaining a sustainable cost balance to avoid damaging its reputation. The utility of the SI is thus affected by two variables: the available budget (B)

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and the number of insured persons (IP) who engage in prevention (N_P), as this can influence subsequent costs:

$$u_{SI} = u_{SI}(N_P, B). \tag{1}$$

With $N_P \leq N$ prevention can be divided into PP and SP:

$$N_P = N_{PP} + N_{SP}. \tag{2}$$

2.1 SCENARIO 1

In the initial scenario, there's no SP provided, leaving the IP to depend solely on their initiative for PP. The IPs proactively engage in PP due to a fear of potential "health shocks." [6] However, evidence suggests that combining PP with SP reduces the probability of such health shocks. [4] Yet, the direct health benefits of PP measures may not be immediately apparent to IPs, resulting in no perceived advantage in this scenario.

The benefits for the SI can be summarized as follows:

$$u_{SI,1} = (N - N_{PP})^{\alpha}(\mu_{SI} N_{PP} - c)^{\beta}, \tag{3}$$
$$\alpha, \beta > 0.$$

μ_{SI} describes the rent per IP for the SI; α and β stand for the division of market resources. The parameter c represents the negotiation costs.

2.2 SCENARIO 2

In this scenario, the SI spends payments z to provide SP. Through cooperation with the IP, an overall concept can be created so that the benefits for SI and IP can be described as

$$u_{SI,2} = N_{PP}^{\alpha}(zN_{SP} - c)^{\beta}, \tag{4}$$

$$u_{IP,2} = (\mu_{SI} - z)N_{SP} - c. \tag{5}$$

2.3 SCENARIO 3

The number of IP executing PP using eHealth ($N_{PP,eH}$) can be calculated with

$$u_{SI,31} = (100 - N_{PP,eH})^{\alpha}(N_{PP,eH} - c - \sigma)^{\Gamma}. \tag{6}$$

By introducing eHealth applications, SI incurs introduction costs of σ. This results in the benefit for SI with the optimized number of IP going to SP by using eHealth applications ($N_{SP,dH}$):

$$u_{SI,32} = (N_{PP,eH} - N_{SP,dH})^{\alpha}(zN_{PP,eH} - c - \sigma)^{\Gamma}. \tag{7}$$

The following applies to IP with μ_{IP} as rent for IP by using eHealth applications:

$$u_{IP,3} = (\mu_{IP} - z)N_{SP} - c + \sigma. \tag{8}$$

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2.4 SCENARIO 4

In the long term, introduction costs for eHealth applications will no longer apply and, for example, troubleshooting costs will also become cheaper based on experience. This means that the values of the parameters from the equations (6)-(8) will change.

3 RESULTS

In order to evaluate how the utility values for SI and IP as well as the market shares of prevention change between the four scenarios, it is necessary to specify values for the parameters:

$$\begin{gathered}\mu_{SI} = 1, c = 5, \\ \mu_{IP} = 2, z = 1.5 \\ \alpha = 0.3, \beta = 0.7, \\ N = 100, \sigma_{1-3} = 25, \\ \sigma_4 = 15.\end{gathered} \tag{9}$$

These values produce the following results for the four scenarios:

Scenario	u_{SI}	u_{IP}	$\sum u$	N_{PP}	N_{SP}
1	51.57	-	51.57	71.5	
2	49.15	20.53	69.68	71.5	51.05
3	42.54	50.65	93.19	79	61.3
4	45.19	38.6	83.79	76	57.2

Table 1. Utility values for SI and IP as well as market share of prevention in four different scenarios

If the social insurance does not offer SP and only supports the PP with measures such as advertising campaigns (scenario 1), its short-term benefit value is the highest at 51.57. However, the total benefit value consisting of the sum of the benefits of the social insurance and the insured persons is lowest in this case.

The benefit value of the social insurance is lowest in scenario 3, while the benefit value of the insured persons is highest. In this scenario, the total benefit at 93.19 is significantly higher than the values of the other scenarios. In addition, 79% of insured persons engage in PP and 61.3% participate in SP programs, the highest values in each case compared to the other scenarios.

4 CONCLUSIO

The results of the game-theoretical model show that the use of eHealth applications can lead to a significant increase in benefits for insured persons despite the associated costs. The number of people practicing prevention and the overall benefit are higher in the two scenarios with eHealth support than in the two scenarios without.

Although the benefit of social insurance decreases in scenario 3 due to the introduction

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costs associated with the use of eHealth, more people are reached and motivated to engage in prevention, so that the benefit for the entire healthcare system should increase in the long term and the costs should be redistributed from inpatient care to prevention.

In scenario 4, however, a certain saturation effect can be observed. Although the costs for the eHealth applications fall in the longer term and the benefits of social insurance increase in comparison to scenario 3, it is no longer possible to motivate quite as many people to engage in prevention as in the previous scenario. Concepts for sustainable prevention behavior are therefore needed. This aspect, as well as aspects of regional differences and the individual abilities and health status of insured persons, could be examined in more detail in following articles.

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