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smartCasaplus - risk-based geriatric health coaching for multimorbid insured persons

Chronic diseases are increasingly determining the incidence of illness in an ageing society and are leading to changes in healthcare needs. A more preventative approach to healthcare is particularly important here, as the burden of disease is influenced by various risk factors that can be explained by an interaction between risky behaviour, psychosocial stress and socio-economic factors. Closely associated with the increased incidence of chronic diseases is multimorbidity, particularly in older age, i.e. the simultaneous occurrence of at least two or more diseases, depending on the definition (Puth et al. 2017). A current analysis of the diagnostic data of 67 million people with statutory health insurance in 2023 shows a multimorbidity prevalence of 31.4% of the total collective and 78.2% from the age of 65 (Schmitz et al. 2023). Multimorbidity was defined as the presence of at least three diseases over a period of at least three quarters.

>> Multimorbidity differs from the related concept of comorbidity, which refers to the combined effects of additional diseases in relation to the index disease in an individual and often occurs in the context of disease clusters. Some diseases and combinations of diseases are particularly common in multimorbidity, with three main patterns emerging from the large number of combinations found in studies: firstly, combinations of cardiovascular and metabolic diseases, secondly, mental disorders (often in combination with physical illnesses) and thirdly, musculoskeletal disorders in combination with different physical diagnoses (Güthlin et al. 2020). As the number of diseases increases, the classification of symptoms and the choice of appropriate treatment options become more complex, the resulting interactions less manageable and increasingly risky for the occurrence of undesirable interactions. This increases the likelihood of undesirable side effects, medication errors and drug interactions, which can even result in hospitalisation. It is not uncommon for multi-medication to also cause non-specific complaints such as tiredness, loss of appetite, dizziness, confusion, tremors or falls. This can lead to further medication prescriptions and hospital admissions.

Multimorbid geriatric patients in particular have a higher risk of dying prematurely, being hospitalised and having a longer length of stay than people with a single chronic condition. Multimorbidity is also associated with poorer functional capacity and health-related quality of life, depression and the use of multiple medications (polypharmacy), as well as higher socio-economic costs. In view of this, the question arises of a service that goes beyond the possibilities of indication-related approaches and, above all, does justice to the situation of people whose health situation is determined less by illnesses and more by interrelated symptoms, complaints and functional limitations that result from the complex interplay of various chronic and acute illnesses, whose respective contribution to the overall situation is difficult to determine and is also often of secondary importance for coping with everyday life. The (geriatric) patient will only be able to be an ‚expert on their illness' in the traditional sense to a limited extent.

Complex courses of illness pose new challenges for medical care, as they increase the urgency of a consistent patient and user orientation: on the one hand, the orientation of care towards individual patient needs, and on the other, the strengthening of patient orientation through the support of empowerment, self-management and personal responsibility of those affected (Burger 2013: 16). A person's self-management skills are particularly relevant in the case of multimorbidity, as people have to deal with several problems and providers at the same time, who may be active in different sectors (Leijten 2018). Healthcare should therefore take into account the needs and preferences of the individual and prioritise common treatment goals (DEGAM 2018).

This results in the need for an individual, patient-centred approach. A holistic understanding of the person in their individual life situation is central to the integrated care of patients with multiple chronic illnesses. The main focus here is on the health of the individual, their well-being and self-care abilities as well as existing resources, e.g. support from relatives (Burger/Habel 2014).

The Casaplus geriatric training programme

Frailty and a lack of knowledge in dealing with several chronic illnesses occurring simultaneously often lead to a lack of independence in the home and social environment for older people. In order to prevent unwanted escalation of crisis situations, maintain or strengthen everyday competence and delay the need for care, preventive measures can effectively support age-specific health promotion (Hildebrandt: 2011). One such offer is the Casaplus geriatric training programme: It has been offering telephone health coaching sessions for multimorbid geriatric policyholders since 2007, and around 30,000 people have already taken part in the programme nationwide to date. It sees itself as a supplement to the medical measures of standard care and implements the recommendations for dealing with multimorbid older people by selecting suitable programme participants by means of risk stratification, jointly defining goals, taking into account needs and preferences, prioritising the topics and issues that cause the greatest suffering from the perspective of those affected and supporting self-management. Casaplus pursues a holistic and personalised approach in which advice and training is provided across all indications rather than focusing on the disease. Casaplus is aimed at insured persons with an increased risk of hospitalisation and enables older people

to receive the right support in each case.

The Casaplus coaching programme comprises a total of seven advisory modules that relate to the typical geriatric risks described above (see Fig. 1). Firstly, the disposition for typical geriatric risks such as malnutrition, risk of falling, adverse drug reactions or social isolation is identified in a detailed anamnesis interview. Assignment to one or more counselling modules is then made between the programme participant and their personal health coach depending on the counselling objective and individual preference or level of suffering.

Based on this, the insured persons are regularly sensitised to possible health risks by their personal advisor, trained in dealing with symptoms and in the early detection of crises and, if necessary, directed to appropriate care structures. In 2023, the programme participants were supported in an average of three to four counselling modules. If the programme participant is assigned to one of the three modules - falls, malnutrition or lack of fluids, or care and social situation - they are offered outreach counselling by a care service. A nationwide network of care services is available for this purpose. The specially trained carers get a precise picture of the participant and their living situation on site, give recommendations for action and, if necessary, intervene at a low-threshold level, for example by pointing out tripping hazards. Modules can be changed during the programme, e.g. due to events that have occurred in the meantime (e.g. further indication, unexpected inpatient stay), and this takes place on a regular basis.

Casaplus thus completes the care of geriatric patients in their familiar environment and strengthens their everyday competence. MedicalContact AG's telephone health coaching is needs-orientated. The aim is to identify the interplay of as many influencing factors as possible that have a bearing on the patient's health and to tailor support accordingly. If desired, the counselling can also extend to the insured person's relatives.

smartCasaplus - with risk-based candidate identification

After ten years of successfully using Casaplus, a comprehensive relaunch was carried out in 2017, initially for VIAC-TIV policyholders. On the one hand, this affected the intervention itself, for example by including the oncology counselling module and updating the counselling content of the other modules. Secondly, the Casaplus coaching programme was expanded into smartCasaplus with identification based on continuously learning risk models, which enable the identification procedure to be continuously adapted based on the latest evaluation results and data.

The smartCasaplus CEP hospitalisation prediction model

The success of Casaplus stands and falls with the identification of insured persons with a sufficiently high risk of hospitalisation. To this end, MedicalContact AG has been using a hospital admission prediction model (CEP model) from DCC Risikoanalytik GmbH since 2017, which is continuously adapted to the Casaplus programme and has the following key changes to the previous model: - In contrast to the LOH model originally used, this is not a static prediction model, but a learning prediction model that is subject to a continuous process of change and is adapted for each identification .
- The hospitalisation prediction model was further developed from a general model to a specific model that focuses on the hospital cases that can be influenced by Casaplus. For this purpose, the CEP target variable to be forecast (as a list of ICD10 discharge diagnoses) is adjusted to the indications that were demonstrably successfully influenced in the previous evaluation period.
- In addition, a GAP-based risk prognosis is used, i.e. a gap of 2 to 3 quarters between the time of identification and the prognosis period is taken into account for the recruitment of participants. This includes the time required for information, recruitment and admission interviews (see Fig. 1). This prevents the predicted inpatient stay from occurring before the intervention can take effect.
- Furthermore, the smartCasaplus CEP model utilises the latest available billing data and also takes into account the typical SHI delays in individual main service areas. For this purpose, a data status analysis and quality assurance is carried out at each identification time and the current LAG pattern (quarters with data delay per main service area) that can be used for the model application is extracted. For the model adjustment, this specific LAG pattern is projected into the past, taking into account the CAP quarters, in such a way that the target variable is fully available in the current data basis for at least twelve current months (see Fig. 2).
- Finally, the CEP model was expanded to include regional attributes to take account of the very different regional supply structures.

The current CEP model is used to identify those insured persons in the population whose Casaplus-specific hospitalisation risk is at least three times higher in the forecast period.

The smartCasaplus impact forecast model

In addition to the CEP model, the impact model is another key component of the programme's continuous focus on the insured persons with the highest probability of success. As part of the

Programme sequence of the Casaplus geriatric training programme

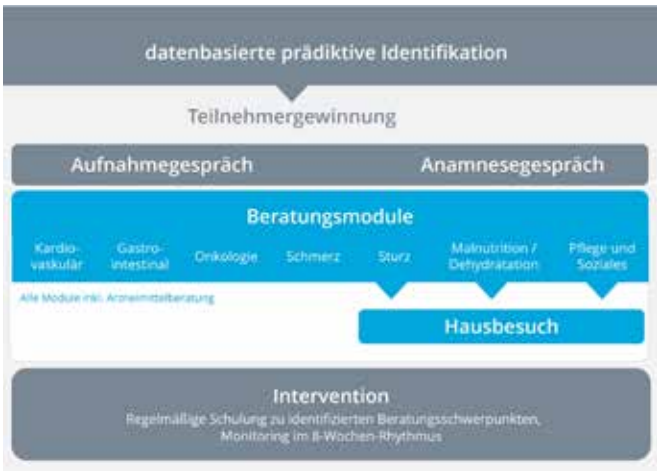


Fig. 1: Programme sequence of the Casaplus geriatric training programme.

annual evaluation, the programme participants for whom a positive effect on the target variable can be measured in the second year of the programme are identified. As part of the ongoing adjustment of the impact model, these form the target group IMP = 1. The impact forecast model is adjusted in the same way as the CEP model on the basis of the current data (see Fig. 2) and evaluation results. By applying the impact model to all candidates identified using the CEP forecast, it is possible to focus recruitment on insured persons with a sufficiently high risk of hospitalisation that can also be influenced by geriatric coaching.

The smartCasaplus SignIn prognosis model

The SignIn prediction model is the third component of the smartCasaplus identification procedure. It determines the probability that the identified candidates will actually enrol in the programme. The aim of this model is to first write to the insured persons who are most likely to participate in the programme in order to maximise the recruitment rate and make optimum use of the limited coaching resources. In the quarterly SignIn model adjustment, all candidates who have been successfully recruited for the programme in the past 3 years, i.e. who have participated in the programme for at least 181 days, form the target group (SignIn = 1). The SignIn forecast is also based on the current data according to the LAG-GAP principle in Figure 2.

The quality of the model is assessed using the area under the Receiver Operator Curve (ROC), the Area Under the Curve (AUC). The ROC describes the ratio of the true positive rate (‚true positive rate' - y-axis - sensitivity) to the false positive rate (‚false positive rate' - x-axis - specificity) for all threshold values (points on the curve). The closer the AUC approaches the ideal value of 1, the more favourable the relationship between the highest possible sensitivity (high true positive rate) and the highest possible specificity (low false positive rate) at the optimum threshold value (vertex).

In order to optimise the AUC of the smartCasaplus forecasting models, the logistic regression methods originally used are gradually being replaced by AI-based, high-dimensional deep learning (MLP Multi Layer Perceptron with 2,453 input nodes, 2 hidden layers and ADAM learning or regression tree method with 2,453 attributes, 12 layers, 6 nodes and Bayesian parameter optimisation). The forecasting models currently used achieve an AUC of between 0.78 and 0.88 (see Fig. 3).

As part of the creation of the smartCasaplus candidate list, a combiscore is finally calculated in which the three forecasting models are weighted differently. The CEP risk has the highest weighting and the SignIn probability the lowest.

Evaluation of the smartCasaplus programme

A total of 2,951 VIACTIV policyholders were enrolled in the smartCasaplus programme as at 30 June 2023. 2,164 of these were valid on the reporting date, i.e. had been receiving care for at least 181 days. For the necessary retrospective long-term study, the 1,673 valid participants with enrolment between 15 September 2017 (relaunch) and 30 June 2022 were assigned to the 10 half-year cohorts in Figure 4 based on their enrolment date.

LAG-GAP principle of model adaptation

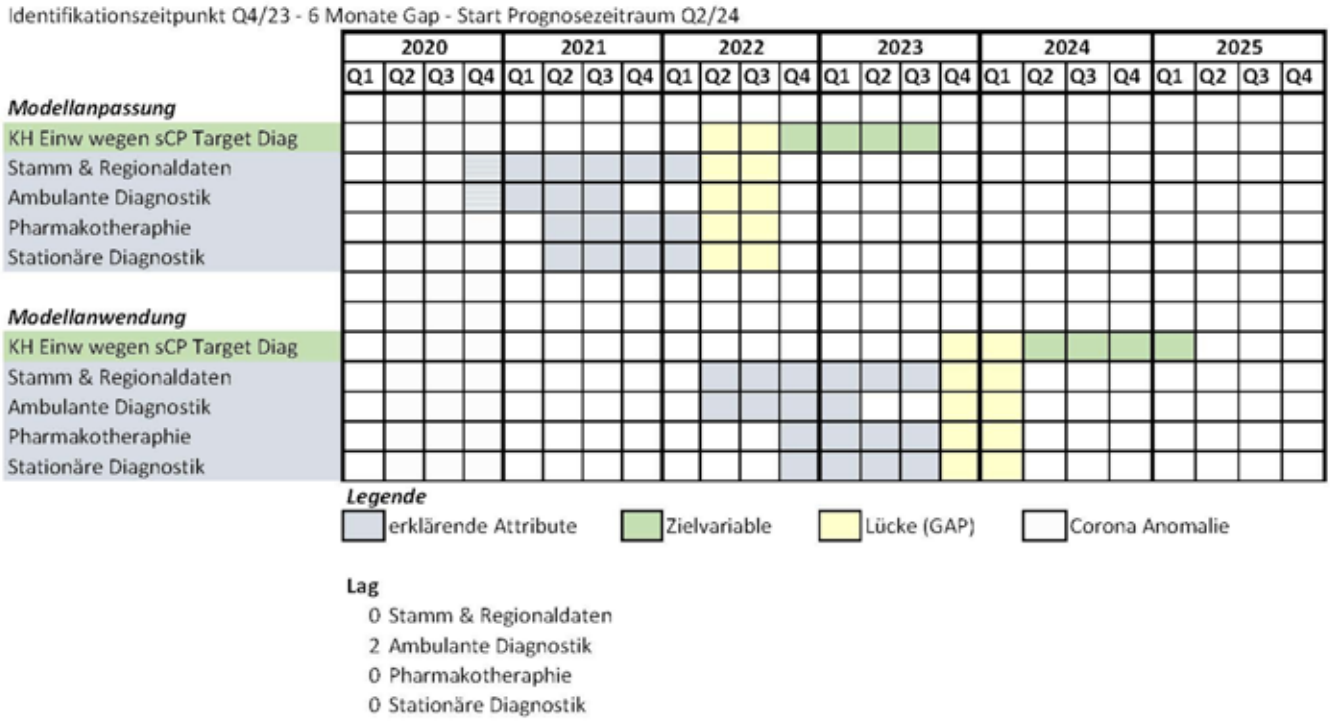


Fig. 2: LAG-GAP principle of model adaptation.

The 100 smartCasaplus participants (sCP) who newly enrolled in a disease management programme (DMP) during sCP participation were excluded from the intervention group to be evaluated. The 1,228 participants who were previously enrolled in a DMP remained in the intervention group. However, in order to minimise bias due to programme overlap between sCP and DMP, these sCP+DMP participants were compared with other DMP participants (without sCP participation) (see below).

The study population for the evaluation comprises approx. 242,000 VIACTIV insured persons who

- were fully insured during the evaluation period (4 quarters before the start of the intervention until the end of the data status) or died after the start of enrolment of the respective co hort,
- were between 60 and 100 years old on the day en rolment began,
- for whom none of the 51 exclusion ICDs were documented either as a confirmed outpatient or inpatient primary or secondary diagnosis during the matching period (4 quarters before the start of the intervention), and
- for whom no care level > 2 and no inpatient care was documented in the matching period.

A major challenge when implementing retrospective evaluations based on billing data is the identification of suitable virtual control groups. Among all insured persons who fulfil the inclusion and exclusion criteria of the study population, a comparison group must be formed from the insured persons who were not involved in the intervention at any time, but whose outcome risk is comparable to that of the intervention participants.

Risk-adjusted propensity score matching (RAPSM)

The propensity score matching method (PSM) has established itself as the most important method for identifying retrospective comparison groups in healthcare analyses (Austin 2014). In this process, multiple individual attributes are tested in a statistical modelling procedure with regard to their significance in explaining participation in an intervention. This model is subsequently used to determine a propensity score for all insured persons in the study population. Matched pairs are formed by identifying a ‚best-matching' partner for each insured person in the intervention group. This ensures that the most similar comparison partner is assigned to each participant in the intervention group, even when multiple attributes from the areas of demographics, regionality, morbidity and therapy are taken into account, and that a comparison group of at least the same size is identified within the study population. The intervention effects on the outcome parameter are then evaluated using two-way comparative analyses of the primary outcome parameter between the intervention and comparison group.

A major shortcoming of the classic PSM method is that the dependent variable of the propensity modelling is the binary coded intervention participation and not the outcome parameter to be evaluated (Kim et al. 2018; Schneeweiss 2009). As a result, although the identified comparison group has a similarly high probability of participating in the intervention, this similarity does not relate to the risk of occurrence of the outcome to be assessed. However, the ability of the propensity model to explain the risk of the outcome to be measured is decisive for the validity of the retrospective comparison group identified in the PSM.

In the risk-adjusted propensity score matching method (RAPSM) developed in the German-Canadian cooperation project AIR_PTE (AI-based Risk Prediction and Treatment Effect estimation) between 2020 and 2022, the attributes of the propensity model are therefore selected using an upstream AI-based risk model of the outcome parameter to be assessed. In the RAPSM procedure, not all available attributes are used as the basis for the subsequent PSM, but only those identified as risk factors using Shapley analysis (Yongchan 2021). The propensity model formed on this basis now explains not only the similarity with regard to the intervention, but also the similarity with regard to the outcome risk (Zahn et al. 2023). As a result, the comparison group identified using RAPSM not only has a similar distribution of propensity scores, but also a similar distribution of outcome risk scores. The subsequent effect analysis is therefore able to determine the effect strength of the intervention on the primary outcome parameter in the cross-section (within a defined time interval after the start of

AUC of the smartCasaplus prediction models

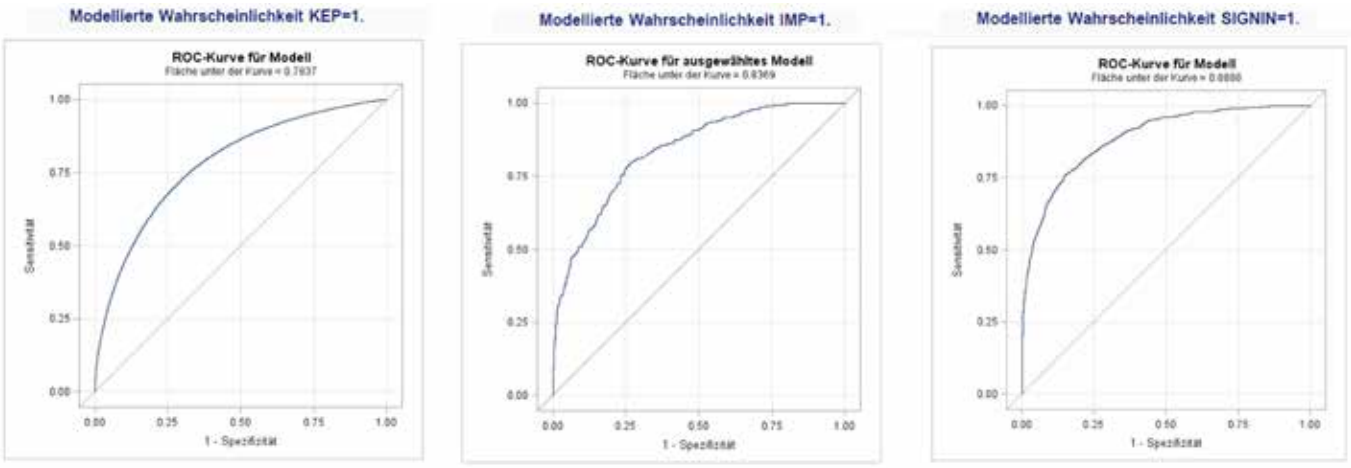


Fig. 3: AUC of the smartCasaplus prediction models.

Cohort allocation of the evaluation

ALL_VALID_TN (bis zum Ende des Datenstandes aktuell 30.06.2023 - mind 181 Tage im Programm)

Kohorte	Anzahl PID	2017				2018				2019				2020				2021				2022				2023			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1	293	0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5				
2	207			0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5		
3	106					0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4				
4	227							0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4		
5	131									0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3				
6	95											0	0	0	0	1	1	1	1	2	2	2	2	3	3	3	3		
7	171													0	0	0	0	1	1	1	1	2	2	2	2				
8	228															0	0	0	0	1	1	1	1	2	2	2	2		
9	130																	0	0	0	0	1	1	1	1				
10	85																			0	0	0	0	1	1	1	1		
Summe	**1673**																												

Legende

0	Matchingzeitraum - 4 Quartale vor dem Quartal des Interventionsbeginns
1	1.Interventionsjahr - 1.-4. Quartal ab dem Quartal des Interventionsbeginns
2	2.Interventionsjahr - 5.-8. Quartal ab dem Quartal des Interventionsbeginns
3	3.Interventionsjahr - 9.-12. Quartal ab dem Quartal des Interventionsbeginns
4	4.Interventionsjahr - 13.-15. Quartal ab dem Quartal des Interventionsbeginns
	zum aktuellen Datenstand keine vollständigen Daten verfügbar
	Corona Anomalie

Fig. 4: Cohort allocation of the evaluation.

the intervention), but also in the longitudinal section (by continuously comparing the development of the outcome parameter in the intervention and comparison group over several time intervals).

Result of the current smartCasaplus evaluation

A risk-adjusted control group is formed for each of the 10 cohorts using the RAPSM method.Participation in the six disease management programmes (to reduce DMP overlap effects) and the SignIn probability (to reduce SignOn bias) are included in the RAPSM model as additionalattributes. The 1:1 assignment of the most similar comparison partner (VG) to each intervention participant (IG) is carried out by means of ‚nearest neighbour matching' without any backward assignment and under the condition of not having participated in the intervention at any time. The effects on the primary outcome parameter hospital costs and the secondary outcome parameters total benefit costs (excluding dentist and sickness benefit) and morbidity allocation (HMG) from the health fund are evaluated iteratively for all 10 cohorts in the 1st to 4th year of the intervention relative to the start of the intervention (see Fig. 4).

A distribution-based pairwise extreme value adjustment is carried out in which all pairs in which the target value of a partner deviates by more than 2 times the standard deviation from the expected value of the target value distribution in the respective intervention year are excluded.

As can be seen in Figure 5 from the development of the mean hospital costs per insured person, the programme effect on the intervention group (IG-red) can be determined on this basis as the absolute deviation from the comparison group (VG-blue) in the matching period and each of the 4 intervention years.

In addition to the number of adjusted pairs and the absolute mean difference, their significance is also determined as the p-value of a two-sided test and their relative deviation in per cent. The criterion for successful matching in smartCasaplus is a non-significant mean difference of < = 5% in the matching period.

The result of the smartCasaplus evaluation 2023 shows a significant effect (p < = 0.05) of geriatric coaching on the primary outcome parameter of hospital costs totalling EUR 3,824 per participant in all 4 intervention years.

By applying the same evaluation principle to the secondary outcome parameter of total service costs (TCO), atotal TCO reduction effectof EUR 3,892 wasmeasured in the first 4 years of the programme as part of the 2023 programme evaluationaccording to the ‚Difference to Difference' principle (D2D).

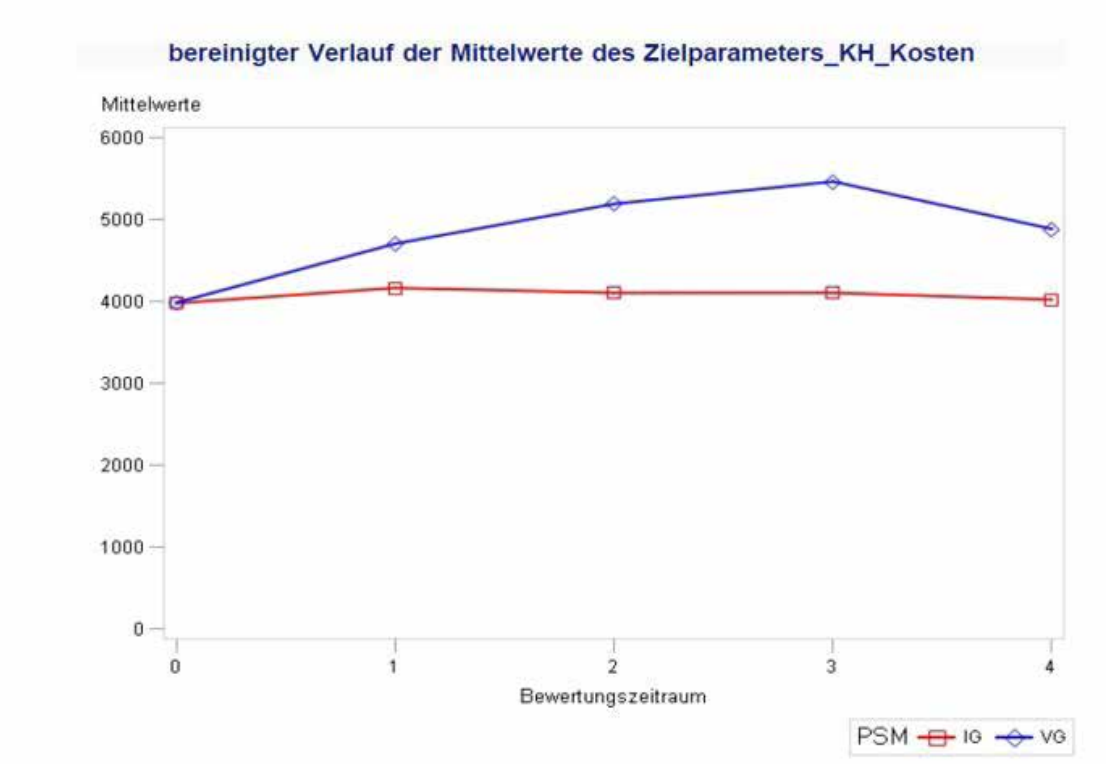
With regard to the secondary outcome parameter morbidity allocation (HMG-Zuw), these expenditure reductions are offset by a revenue reduction effect of EUR 938 in the first 4 programme years , which only occurs from the 2nd programme year onwards due to the prospective nature of the morbidity allocation.

In the calculation of the return-on-investment factor (RoI) for the smartCasaplus programme shown in Figure 6, the average programme costs per participant for the service provider Medical-Contact AG are taken into account in addition to the cost and revenue reduction. In the first year of the intervention, the acquisition costs incurred before the start of the intervention are also included. As can be seen in Figure 6, the result of the smartCasaplus evaluation 2023 is an ROI of 1.1 in the 1st programme year and a total ROI of 1.7 in the first 4 programme years.

Conclusion

Data-based risk prediction makes it possible to use modern

smartCasaplus evaluation result 2023 - hospital costs 1st-4th year of intervention



	Programmjahr	IGmembers	VGmembers	IG_Mean	VG_Mean	VGIGmeanDiff	pValue	Programm	
Matching - 4 Quartale vor Interventionsbeginn	0	1510	1510	3.982	3.988	6	0,9742	-	0,2%
1.-4. Quartal der Intervention	1	1543	1543	4.168	4.708	540	**0,0222**	823.701	
5.-8. Quartal der Intervention	2	1196	1196	4.108	5.195	1.087	**0,0001**	1.292.283	
9.-12. Quartal der Intervention	3	795	795	4.108	5.468	1.359	**0,0002**	1.075.615	
13.-15. Quartal der Intervention	4	532	532	4.025	4.889	863	**0,0242**	455.931	
1. Programmjahr D2D				186	720	**534**			
2. Programmjahr D2D				126	1.206	**1.081**			
3. Programmjahr D2D				127	1.479	**1.353**			
4. Programmjahr D2D				43	900	**857**			
1.-4. Programmjahr D2D						**3.824**			

Extremwertbereinigung
paarweise kombiniert > 2.0 σ

Fig. 5: smartCasaplus evaluation result 2023 - hospital costs 1st-4th year of intervention.

AI-based identification methods to focus patient-centred care programmes of health insurance companies on high-risk patients whose risk can be particularly well influenced by the respective intervention. AI-based methods such as RAPSM can also be used in the ongoing evaluation of healthcare programmes to determine valid and statistically significant effects on expenditure and income and use these to continuously optimise the identification process. The Health Data Utilisation Act, which comes into force on 1 February 2024, creates further opportunities for health insurance companies and service providers to use these methods in healthcare practice.

As can be seen from the example of the smartCasaplus geriatric coaching programme, focusing on geriatric coaching using adaptive prediction models makes it possible both to use the insurance premiums used for this purpose economically and to provide patient-centred individual care for insured persons who are particularly in need. Individual coaching programmes such as smartCasaplus can reduce the demographically-related growing gaps in holistic and patient-centred care, particularly in the psychosocial area, and achieve considerable effects for the benefit of the SHI community. <<

Calculation of the return-on-investment factor (RoI) for the smartCasaplus programme

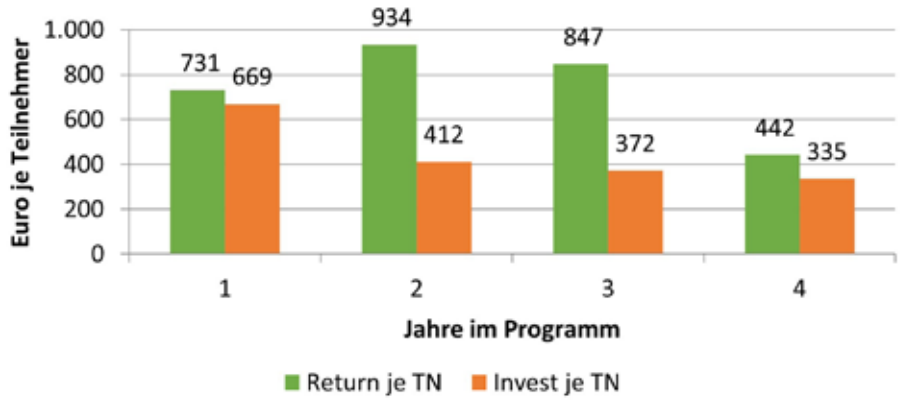


Fig. 6a: Calculation of the return-on-investment factor (RoI) per participant for the smartCasaplus programme..

smartCasaplus programme effects per intervention year

nach der Compare to Control Messmethode

	Programmjahr	TN	HMG Zuw je TN	GLK je TN	Return je TN	Invest je TN	Netto je TN	RoI	Return Summe
1.-4. Quartal der Intervention	1	1573	181	550	731	669	62	1,1	1.150.213
5.-8. Quartal der Intervention	2	1422	- 145	1.079	934	412	522	2,3	1.328.544
9.-12. Quartal der Intervention	3	1023	- 456	1.303	847	372	475	2,3	866.880
13.-16. Quartal der Intervention	4	797	- 518	960	442	335	106	1,3	351.973
	total 1-4 Jahr		- 938	3.892	2.955	1.788	1.166	1,7	3.697.609

Fig. 6b: smart Casaplus programme effects per intervention year.

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Authors' declaration

The authors declare that they have contributed to the analysis of the data and the interpretation of the results free of charge. M. Müller as Chairman of the Board of VIACTIV is the client, S. Burger as Managing Director of MedicalContact is the provider and T. Zahn as Managing Director of DCC is the evaluator for the smartCasaplus programme.

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