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# Planning medical care for actual need

## Developing a model to ensure the provision by physicians of universal office-based medical care based on actual need

Gerhard Fülöp · Thomas Kopetsch · Pascal Schöpe

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### Abstract

**Aim** When it came into force on 1 January 1993, the Health Structure Act brought about far-reaching changes in the German health system by completely reorganising needs-related planning for office-based medical care. The experience to date suggests that needs-related planning is having an effect. Since the law came into effect, the increase in the number of doctors has clearly levelled off, and in certain fields the trend can even be said to have been reversed. Indeed, needs-related planning will in future have to address a completely new issue, one that only a few years ago was considered inconceivable: a looming lack of doctors. It is precisely in this context that needs-related planning, an arrangement conceived when the number of doctors was rising, can be seen to have strategic flaws. It has now become clear that the data (population, number of doctors) and information on structures (geographical planning units) drawn on in needs-related planning to indicate the degree of provision are unsuitable for ascertaining the need for, and controlling the supply of, office-based medical care. Indeed, the current needs-related planning hardly justifies its name.

**Subjects and methods** There is a need for genuinely strategic planning that, rather than measuring the status quo in isolation, takes due heed of likely future trends in such factors as population and the number of doctors.

**Results and conclusion** The reversal of the trend from over- to undersupply of medical care has brought about an increasing scarcity of points of access. If the Associations of Statutory Health Insurance Physicians are to meet their legal commitment to provide universal medical coverage, it is essential that an analysis of the relationships within the care supply network be carried out. A potential solution to this problem is offered by “regional studies interaction models”, which model the physical accessibility and convenience for patients of supplier locations (here: office-based physicians) and the response of the demand side (here: the patients) to the existing geographical constellations.

**Keywords** Needs planning · Health services · Office-based medical care

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### Introduction

In Germany the discussion about the provision of health care by office-based statutory health insurance (SHI) physicians has shifted its focus. In the 1990s the predominant objective was to put an end to the increase in oversupply. This led, in particular, to the introduction of the present needs planning system and the announcement of the introduction of medical licences based on ratios stipulated by law. Today, despite the ongoing *de facto* ban preventing specialists establishing new practices in urban conglomerations, the discussion is dominated by the fear of

undersupply in rural areas with weak infrastructure. Legislation reflecting this new development was first introduced in the 2003 Statutory Health Insurance Modernisation Act (*GKV-Modernisierungsgesetzes*), which included the following measures:

- The possibility of paying supplementary fees to statutory health insurance physicians in undersupplied areas as a premium for ensuring the supply of medical care.
- Allowing hospitals to provide outpatient care in undersupplied regions.

Despite these measures it is proving increasingly difficult today to ensure the universal availability of medical care, particularly in peripheral areas. As will be seen later, just when it is required to live up to its name, needs-related planning is unable to define what is necessary to fulfil need. Attempts to alleviate this problem have failed.

On 1 January 2003 the instruments included in the needs planning guidelines to combat oversupply were to be replaced by statutory need-related medical licences. (The relevant legislation is contained in §102 of Germany's Fifth Social Law Code.) The federal ministry of health commissioned a scientific report that was to set objective criteria for establishing the number of doctors required as a basis for the introduction of these licences. The report was presented to ministry staff and representatives of both the statutory health insurance institutions and the SHI doctors in April 2002 (Potthoff and Schneider 2002). The thesis propounded in the health economics literature that the need for medical benefits and thus also the need for doctors cannot be objectively established was confirmed. The report stated that it was only possible to assess medical need in terms of indicators that were all subjectively selected and thus subject to a certain arbitrariness.

The needs planning directives (see Sect. 3) of the GBA (*Gemeinsamer Bundesausschuss*/Joint Federal Committee of Statutory Health Insurance Institutions and Associations of SHI Physicians) continue to circumvent this problem by defining need as a ratio of doctors to population. This means accepting as an adequate and appropriate level of medical care a doctor/population ratio based on the number of SHI doctors per head of population in 1990. The conceptual weaknesses of this global capacity planning based on ratios are becoming increasingly evident. This stresses also the expert advisory board for the concentrated action in the public health service: Diese Richtziffern liefern Informationen über den Umfang eines Angebotes. Sie sind allerdings für eine Betrachtung im Sinne der Definition des Rates zu einer bedarfsgerechten Versorgung nicht ausreichend". ["These direction numbers supply information about the range of the proposal. They are

however not sufficient taken into account the definition of the expert advisory board concerning the Medical Care for Actual Need", SVRKAG (2001), p. 3]. Needs planning is incapable of probing below the surface to the details of health care provision in any given locality. It is thus increasingly common in eastern Germany, for example, to find communities where as a result of abandoned practices and poor infrastructure there are no doctors within a reasonable distance. Yet the level of medical provision calculated for the planning areas in which these communities are located precludes any suspicion of undersupply. Adequate care is not generally available even in some planning areas for which, because of a theoretical oversupply, no licences for new practices can be granted. This is the case, for instance, where doctors are concentrated exclusively in urban areas and cannot be reached from outlying areas with poor infrastructure. This makes clear that viewing the level of care in isolation is no longer sufficient for a supply-based needs planning system. It is not enough, then, to question the levels of undersupply (For general practice undersupply is assumed to exist below a supply level of 75%, whilst the figure for specialist care is 50%.) at which, according to the directives, the system must intervene. It is rather the current system of needs planning itself that must be called into question.

There can be no guarantee of medical care provision by SHI doctors as long as countermeasures can only be introduced when undersupply has become universal. While the creation of financial incentives as a means of controlling care provision in undersupplied regions might offer a solution, the needs planning system's field of vision is as yet too global for the identification of such areas. The model for small-scale analyses of care provision presented in Sect. 3 could provide help in remedying this deficiency, making it possible to remove such local disparities.

### The analyses of the actual needs planning system

In Germany doctors require a licence as a 'contracting physician' to be able to practise and provide services for the account of the statutory health insurance system. The licences are granted by the responsible regional licensing committees, which are composed of equal numbers of representatives of the medical profession and the statutory health insurance institutions.

The Health Structure Act (*Gesundheitsstrukturgesetz*), which came into force on 1 January 1993, completely reorganised needs planning and thus brought about one of the most far-reaching changes in the provision of medical care by SHI physicians. The key element of this regulation is concerned with the definition and identification of oversupply and the resulting 'closure' of the relevant

planning areas to specific medical specialists seeking to open new practices. This form of needs planning was stricter than its predecessor and was regarded as essential for preserving the financial viability of the statutory health insurance system. The government assumed that the increasing number of contracting physicians was one of the major causes of rising costs in the health system. The ultimate purpose of needs planning was to guarantee that fewer doctors would be able to establish their own office-based practices.

The structure of the new needs planning guidelines (*Bedarfsplanungsrichtlinien*) drawn up by the Federal Committee of SHI Institutions and Physicians (*Bundesausschuss*) can be summarised in three main points: calculation of ratios, definition of the ‘planning areas’ as counties and county boroughs (municipalities with their own independent administration at county level), and exceptional arrangements for quality-related “determination of special need” (Kopetsch 2003). The aim was to categorise counties with similar structures into groups and to calculate a separate ratio for each group. The strategy of the needs planning guidelines is thus based on a subdivided ratio. Drawing on the land division model used by the Federal Office of Building and Regional Planning (*Bundesamt für Bauwesen und Raumordnung*), this system came up with three basic types of region (regions with large concentrations of population, regions with moderate concentrations of population, and rural regions), subdivided into nine categories of county or county borough, supplemented by a separately defined special region. (The Ruhr conurbation, which because of its unique structure did not fit into any of the categories thus formed, was accorded its own ratio.)

The newly formed planning areas corresponded to this system of land classification. As a rule, the planning area was thus defined as a county or a county borough. On the basis of the new land classification, a ratio was then calculated for the ten different categories of area by adding up the numbers of inhabitants and statutory health insurance doctors in all counties of the same category on the qualifying date of 31 December 1990 and then dividing them by each other.

This resulted in ten ratios per group of doctors (expressed as percentages). Fourteen groups of specialists are currently planned. Specialities with fewer than 1,000 SHI practitioners nationwide are not subject to needs planning.

The population/doctor ratio established on the qualifying date for each planning area and each medical speciality is compared with the general ratio by the relevant state-level committee, composed of doctors and representatives of the statutory health insurance institutions. The result is the level of care supply expressed as a percentage. The Fifth Social Law Code lays down that a planning area with a level of supply of over 110% must be “closed” by the state-level

committee responsible. All other planning areas, i.e. those with a supply level of under 110%, are regarded as “open”. In these, SHI doctors are free to establish new practices. New licences for closed areas are only available for doctors taking over an existing practice or in exceptional cases when the licensing of a further doctor is considered “imperative” to ensure adequate care provision for special need.

Since 1994 the increase in the number of doctors has levelled off. In the period from 1994 to 2005 the rate of increase for specialities subject to needs planning averaged around one percent. The geographical distribution of doctors has become more even as doctors wanting to establish their own practices have been diverted to planning areas that were not “closed” to their speciality. In principle, then, needs-related planning is having an effect. The needs planning guidelines have not been able to remove an existing local oversupply in some areas (e.g. cities) as they include no instruments for closing practices in oversupplied areas or preventing the practices of retiring SHI physicians being taken over by a successor. Nor has needs planning been able to prevent the ratio of general practitioners to specialists changing in favour of the latter. Whereas in 1980 there were still 65 general practitioners (including paediatricians) for every 35 specialists, by 1993 this ratio had reached 59.7 to 40.3. The trend has continued up to the present so that in 2007 the ratio was around 48.8 to 51.2. The consequence is that in Germany there is a *de facto* embargo on new practices for specialists, although retiring specialists continue to be replaced. General practitioners find themselves in a completely different situation. Since numerous planning areas across the whole country are open to them, they are free to establish a new practice wherever they like.

For years Germany was said to have an oversupply of doctors. A study by the KBV (*Kassenärztliche Bundesvereinigung*/National Association of Statutory Health Insurance Physicians), presented to the public in 2002, showed that Germany, and particularly eastern Germany, would soon be suffering from a shortage of doctors unless timely and sustained countermeasures were taken (Kopetsch 2001; on behalf of the statutory sickness funds this view has been contradicted, see for example Klose et al. (2003) and Klose et al. (2007).

There are two reasons for this development: firstly, an extremely unfavourable “top heavy” age profile (especially in eastern Germany) and, secondly, a simultaneous slump in the number of new young doctors. These developments make it necessary to confront the problem of undersupply. In particular, the existing undersupply thresholds (75% for general practitioners and 50% for specialists) require careful scrutiny in the light of the realities of current medical care provision.

It is becoming more and more difficult for the *KVs* to meet their commitment to guarantee the provision of medical care. The following examples will serve to highlight the fundamental shifts taking place:

- The role of the general practitioners as ‘pilots’ within the German health system has been further strengthened by the Statutory Health Insurance Modernisation Act (*GKV-Modernisierungsgesetzes*), which promulgated the concept of GP-centred care. Since specialists prefer to locate their surgeries in centres of population, people in rural areas usually turn first to GPs with their health problems. It is thus becoming increasingly important to secure the long-term future of general practitioner services in all areas.
- The demographic structure of the populations of the eastern states of Germany is already less favourable than in the rest of the country. Due to the structural problems there, demographic change is taking place more rapidly in the east and the problems ensuing from an ageing population will become even more acute. General practitioners constitute one of the groups for whose services demand increases disproportionately as a population ages. At the same time, the proportion of older doctors in eastern German is higher than the national average. In the next 3 to 5 years, a third of all general practitioners will need to be replaced.
- Because of the general practitioners’ *de facto* freedom to establish new practices wherever they want, GPs cannot simply be ‘stationed’ where they are most urgently needed. Many doctors prefer to take up practice in western Germany.
- There are noticeably more regional disparities in the provision of medical care in eastern Germany. For example, in Brandenburg, the state which surrounds Berlin, the clustering of practices along the boundary with the German capital contrasts with more remote areas of the same state, where medical care is in increasingly short supply.

These phenomena suggest the following problem areas for the current system of needs planning:

- With very few exceptions, measuring the level of medical care in isolation suggests an adequate supply throughout the country. Despite this statistical sufficiency, it can already be assumed that in many local areas the provision of medical care is inadequate.
- No attention is being given to the geographical distribution of SHI physicians. No procedures for measuring distribution disparities are being adopted.
- The index number method used in needs planning to assess the levels of care provision cannot cope with situations both involving relations between regions

and at the same time requiring precise statements at a low regional level (e.g. location planning for office-based physicians, assessment of care provision disparities at an intra-regional level). The reason for this is that a region being supplied with medical care from outside its own boundaries usually appears to be suffering from too low a supply density, while a region providing medical care to its neighbours appears to be oversupplied, whereas in reality there is often mutual compensation. However, this ‘truth’ cannot be represented because index number methods work with ‘rigid’ boundaries for supply areas, which fail to reflect the complex reality of patient migrations and the travelling times patients incur (Fülöp 1999).

- The actual contribution made by an individual doctor to overall health care provision is not being ascertained, although the degree to which doctors contribute to the total supply is by no means homogeneous, depending on a variety of factors (surgery hours, utilisation, etc.). Instead, the absolute number of doctors is used to calculate the level of supply. Yet until and unless full-time physician equivalents are taken as reference units, it must remain doubtful whether the quality of care provision is being appropriately represented. The same situation obtains in respect of the assessment of the potential demand with which the supply of medical care is compared. Here, too, the calculations are based on absolute population figures. No demographic factors are included when calculating the level of care provision, although empirical analyses have shown that even with the low spatial resolution at the planning area level, the age profiles are widely scattered. The differences become even clearer when, in order to measure the expected relative treatment costs of a person on the small scale of the local government area, not the age but the relative individual morbidity risk [the relative risk score (RRS) describes the expected need of benefits for every classified insured person or patient using the mean value normalised to 1.00] is aggregated. What we must bear in mind, then, is that neither on the supply nor on the demand side are regional differences incorporated into needs planning. As it is currently practised, needs-related planning is based on the status quo and is thus not designed for an undersupply scenario. There is a lack of dynamic factors (such as the prospective developments in the numbers of doctors and population) that could assess the future care situation. The currently stipulated undersupply thresholds mean that counter-measures are only introduced when the crisis has already set in.

### Developing an application for the small-scale analysis of medical care provision

Operative needs planning still suffers from a description of health care provision simply in terms of its ‘level’. What is lacking are strategic plans for ensuring the supply of medical care when circumstances change. Concrete needs plans, formulated in practical detail, would make it possible to establish the actual ‘reality’ on which to base future planning. Since, in the past, ensuring the supply of medical care presented few difficulties, it is not common practice for the *KVs* to draw up plans. For this reason, in 2003 the *KBV*, their national umbrella organisation, made the first attempts to develop model needs plans.

The first prototype needs plans were drawn up for the planning area of Uckermark, contrasting at the level of local government area the aggregated values for the supply of, and demand for, medical services. This process revealed that many of the factors that determine the relationship between the location of medical practices and the provision of medical care to residential communities had to be ignored when the methodological approach was based at this level. The next objective was therefore to build up an information system that could visualise small-scale care provision situations. The structure of the patient group and its geographical distribution within the local government area, the locations and capacities of the doctors’ surgeries and the ease with which they could be reached were particularly relevant factors here.

In order the better to display the multiple factors and dimensions involved in this information, a geographical information (GI) system was built up. The essential advantage of this system over the needs plans created with mapping software was the improved spatial resolution. Specially ‘tailored’ areas of settlement were taken as reference units. As a result of this change, the number of units to be investigated rose from around 12,500 to 70,000. The next step was to correct the population figures for the areas of settlement by a demographic factor based on the local government area in order to achieve improvements in connection with small-scale demand. (A further “milestone” in the improvement of the estimation of potential need is currently being developed. The model calculations will in future incorporate the actual morbidity via the need of benefits ascertained by means of the RRS.) Additionally the data set for the population was expanded to include population forecast data. The doctors’ surgeries were then geocoded and, using this extremely precise information, the values were aggregated at the area-of-settlement level. This calculation was based both on the absolute number of doctors and on the physician full-time equivalents, which

were calculated by reference to the number of cases per doctor. [A treated case is defined by the Federal General Contract for Medical Practitioners (*Bundesmantelvertrag–Ärzte*) as the entire treatment carried out by the same SHI doctor in the same quarter on the same patient for the account of the same statutory health insurance institution.] Since it was not possible to reach any conclusions concerning the ease, in terms of distance and travelling times, with which the “units of supply” could be reached by the “units of demand” by reference to their geographical location alone, the last step was to integrate detailed data concerning the road network into the model in order to be able to assess patient streams. Determining the catchment area for the medical capacities investigated proved a particular challenge.

The final but decisive stage was the analysis and interpretation of the results. For this it was necessary to carry out a model calculation of the relationships between the locations, a process that proved unsatisfactory when done using the *KBV* model. Neither the isochronic method, where the overlapping of the polygons established creates an allocation problem, nor the Voronoi (Thiessen) polygon method, which delineates catchment areas clearly on the basis of proximity to the measuring points (surgeries), could reliably describe the care provision quality. Both the capacity and the attractiveness of competing locations determine the supply quality ‘on the spot’ and must therefore be included in strategic location optimisation concepts. A further problem occurred with the methodological approach for capturing travelling times on the basis of the digital road network. Because of the enormous amount of computing involved, this proved possible only for certain subregions in the form of individual queries. It was possible to overcome this final hurdle by integrating into the *KBV*’s needs planning concept a regional studies interaction model developed by the ÖBIG (*Österreichisches Bundesinstitut für Gesundheitswesen*/Austrian Federal Institute for Health). This models the physical accessibility and convenience of supplier locations and the response of the demand side (patients) to the existing geographical constellations without any rigidity or ‘impermeable’ regional boundaries. In assessing the physical accessibility of statutory health insurance doctors’ surgeries, a method based on individual transport connections was used. Road networks can be represented by graphs and their structure interpreted using graph theory. A graph consists of a quantity of ‘nodes’ (e.g. intersections) and a quantity of ‘edges’ (roads of different classes). To represent road systems using graph theory, locations (here: areas of settlement) can be interpreted as point-shaped nodes on a ‘road graph’ and the road between them as edges (Böckmann 1982). From the road graphs created by linking the locations in this way, ‘shortest route travelling times’

were calculated. This is the time taken to travel between any two areas of settlement by the fastest route. The result of these calculations (expressed in travelling minutes) was stored in a ‘shortest route matrix’ (SRM). The computed travelling time took account of the average speeds for the relevant road segments. Although the calculations are based only on the travelling time ‘in one direction’, the matrix contains approximately 2.5 billion computed distances  $(70,000 \times 69,999)/2$ . To improve computing times, separate extracts of the shortest route matrix were made for each *KV* including a buffer zone extending roughly 75 km beyond the boundaries of each association’s region. The availability of a shortest route matrix calculated for the whole of Germany was essential for the implementation of the ÖBIG model. Based on Huff’s (1963) probabilistic gravitation model as developed by Bökemann (1985), the number of migrations between the locations is interpreted as the result of the gravitational pull of the provider locations that affects the ‘mass’ of population in the care provision area as a result of the sum of the drawing power exerted by the ‘masses’ of the providers distributed in the local government areas. From this theoretical deductive model it is possible, for example, to ascertain the expected number of physician contacts at a certain provider location or the number of expected contacts per individual doctor. For this, key parameters that determine the drawing power of a surgery location (see below) are integrated in the algorithm. In addition to a status-quo analysis, it is possible, by changing the number and location of the doctors, to ‘simulate’ what effects these changes would have. Additionally, a location optimisation tool could be developed from the model results. For instance, the following questions could be answered:

From the doctors’ point of view:

- What effect will the opening of an additional SHI doctor’s surgery at location *x* have on the flow of patients to the surrounding surgeries?
- Approximately how many doctor contacts could a SHI doctor expect if s/he established a surgery at location *x* in addition to the existing surgeries?
- What effect will the opening of a new practice or the takeover of an existing practice at location *x* have on the surgeries at location *y*?

From the patients’ point of view:

- What are the average journey times to the nearest surgery?
- What choices/capacities are available per provider location (number of office-based physicians)?

Out of a total of nine indicators developed to describe the supply situation, four are presented here. The description of indicators is based largely on Fülöp (1999):

In the KBV/ÖBIG model the **Potential** (Pot) is calculated using the equation:

$$Pot_i = \sum_{j=1}^n \frac{A_j^\alpha}{e^{d_{ij} \cdot \beta}}$$

where

- |                         |  |
|-------------------------|--|
| Pot <sub><i>i</i></sub> | Potential SHI doctors at residential location <i>i</i> (demand side) |
| A <sub><i>j</i></sub>   | Capacity(-ies) of the practices at provider location <i>j</i>        |
| d <sub><i>ij</i></sub>  | Travelling time between the locations <i>i</i> and <i>j</i>          |
| <i>n</i>                | Number of areas of settlement  |
| α                       | Attractiveness parameter   |
| β                       | ‘Distance sensitivity’ parameter                                     |

As a parameter of ‘distance sensitivity’, β indicates the decrease in the attractiveness of the provider as travelling times increase. Thus, when β=0.1, a full-time equivalent general practitioner (i.e. 1.0 FTE) practising a 9-min drive away is still ‘worth’ 0.4 FTE, when β=0.18 s/he is only worth 0.2 FTE and when β=0.25 only 0.1 FTE. (A study using real data is currently being carried out to establish the extent of recognisable regular patterns in the catchment areas of specialists subject to needs planning so that β can be calibrated for the different specialities.) The fact that increasing distance is assumed to reduce attractiveness was the main reason for raising the original level of resolution and reducing the spatial unit from local government area to areas of settlement. This sidesteps two problems: on the one hand, because of the aggregation all the suppliers in a local government area appear to have the same attractiveness; on the other hand, the ‘mass’ of demand, as an entirety, is subject to the drawing power of the surrounding supplier locations. Although the quantity of data is drastically increased when a high-resolution approach is adopted, the improved quality of the results obtained more than justifies the effort and expense. This can best be explained by reference to Berlin. Although the city of Berlin covers an area extending 38 km in a north-south direction and 45 km on an east-west axis, a study based on the local government area would suggest that there is no distance between the patients and the doctors in this area. Moreover, the supply of doctors, taken as an undifferentiated whole, would exert a disproportionate gravitational pull on the surrounding countryside, which lies in the separate state of Brandenburg.

By means of the parameter α, it is possible to weight the attractiveness of each provider. When examining the potential, however, all relevant capacities at the provider locations in the surrounding area are not set in relation to the quantity of patients creating the demand in this area, thus ignoring the risk of supply bottlenecks. To correct this deficiency, the potential density (PD) is calculated for a

comprehensive description of the local supply situation. This is achieved by means of the following equation:

$$PD_i = \frac{\sum_{i=1}^n E_i \cdot e^{-d_{ij}\beta}}{\sum_{j=1}^m A_j \cdot e^{-d_{ij}\beta}}$$

where

$PD_i$  potential density at area of settlement  $i$   
 $m$  number of provider locations  $j$   
 $n$  number of areas of settlement in the planning region.

The use of potential density to provide a summary assessment of the supply situation with high geographical resolution (the area of settlement level) proves very successful in practice. It combines several advantages, incorporating the following aspects equally and simultaneously: the ease with which the provider locations in the surroundings can be reached, the capacities available at these provider locations and the representation of possible capacity bottlenecks. (These last can occur despite high potential at the local government area level as a result of a relative excess of patients in comparison with a relative shortage of available capacities.) To ascertain the ‘migrations’ between residential and provider locations, HUFF formulates a model based on probability theory assumptions (Huff 1963). Applied to health planning, this ‘model of opportunity preferences’ can be used to model the ‘migrations’ of patients at residential location  $i$  to the capacities  $A_j$  at the competing provider locations  $j$ . The calculation, modified from HUFF’s original version, is formulated as follows:

$$p_{ij} = \frac{A_j^\alpha \cdot e^{-d_{ij}\beta}}{\sum_{j=1}^n A_j^\alpha \cdot e^{-d_{ij}\beta}}$$

where  $\sum_{j=1}^n p_{ij} = 1$  and  $p_{ij}$  = probability of the interaction from  $i$  to  $j$ .

From the patients’ perspective (i.e. from the demand side) the **distance expectation value (DEV)** calculated from this interaction probability is of considerable interest. The DEV is derived from the expected interaction behaviour  $p_{ij}$  between the residential locations of the patients  $i$  and the provider locations of the general practitioners  $j$  as:

$$DEV_i = \sum_{i=1}^n p_{ij} \cdot d_{ij}$$

where  $DEV_i$  = distance expectation value for the residential location (area of settlement)  $i$  and gives the average travelling time that will be taken by the patients from

residential location  $i$  for their visit to the doctor when this interaction behaviour occurs.

The care provision index VX was conceived specifically for a ‘holistic’ perspective and to facilitate the choice and optimisation of locations. The aim was to combine the results of the various indicators that reflect the supply situation from different perspectives into an overall result. As a dimensionless indicator that can fluctuate between 0 and 100, it combines the results for PD and DEV. As described, the potential density gives an excellent picture of the supply situation at the local level and above average waiting times are probable for regions with relatively high values. On the other hand, there can be regions that appear from their potential density analysis to be ‘adequately’ provided for, but where, because of a high distance expectation value, the potential (very ‘good’) supply cannot be adequately ‘reached’ by patients from the surrounding area for which it is theoretically available. Care provision ‘close to home’ is of particular importance in general practice. A glance at the care provision index provides information on both aspects. Within the care provision index PD has a weighting of 60%, the DEV 40%.

## Conclusion

The use of a regional studies interaction model creates new possibilities for planning the supply of medical care in the ambulatory care sector to reflect both reality and regional differences. In contrast to a simple visualisation of supply and demand, which requires a (subjective) interpretation from the viewer, the model delivers objectively quantifiable results and the model satisfies the requirements of the expert advisory board to a great extent. The same is true of classical procedures for measuring inequalities, which can sometimes be expressed by concentration measurements such as the Gini coefficient. However, in the field of medical care density spatial features must first be defined. The extent of the effects of exchange between well and poorly supplied regions is not considered. The results derived from the model could form the basis for more reliable planning statements coupled with sophisticated control mechanisms at a level far below the ‘global’ large-scale assessment of supply level adopted to date. With a view to achieving integrative planning of medical care provision, however, ways must also be sought to include the hospital sector. Yet this will only prove possible when a clear demarcation between substitutive and complementary contexts has been made. Both small-scale and large-scale disparities in the provision of medical care can be represented cartographically, as all indicators ascertained at the level of areas of settlement

can be aggregated at higher levels with a population weighting.

**Conflict of interest** The authors confirm that there are no relevant associations that might pose a conflict of interest.

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