Modelling the ambulant health-care sector in Germany

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Abstract
Demographic ageing is a process in Germany that set in decades ago and that affects many different areas within the economy, such as the social security system including health care. The ageing population is characterised by age-specific diseases and frequencies of illness. This suggests a structured planning of the complex health care market. A model that equally considers the supply and demand side in great detail can help to identify undesirable trends and mismatches. It also offers the opportunity to conduct impact analyses in order to display the effects of policy measures or incentive schemes. The modelling routine follows a demand-supply combination. For the supply side model a stock-flow-approach is used considering the complete professional life of a physician. The modelling approach regarding demand takes the demographic development as the central driver. Comparing supply and demand helps to determine shortages or sectors with a sufficient number of specialists so that the planning process can be adapted and improved. Moreover, competing relations between ambulant and in-patient sectors for specialists can be detected.
Introduction

Germany is represented by an ageing population. The consequences of ageing has been debated by researchers and politicians in Germany for years. There has been identified many different areas that are affected by demographic change. The central ones are public finances (especially concerning health- and long-term care), labour market, production and economic growth, demand for goods and services, financial markets as well as export (Sachverständigenrat 2011, BMI 2011, European Commission 2011). With regard to the health-care sector, a particular interest has concerned the further development of the respective workforce, motivated by the predicted shortages in certain health professions. At first glance, the medical profession seemed not to be excessively affected by the development, as there has been a steady increase in the number of physicians practising in the statutory health insurance system. However in the last years there have been challenges in securing the provision of new physicians in less densely populated rural areas as well as regions with a weaker economy and infrastructure. Furthermore there are new concerns about a sufficient provision with new physicians in certain disciplines, such as general practitioners who are prepared to go into rural or less attractive regions.

This study is the first extensive analysis of the future development of the medical profession in Germany by using a modelling approach, bringing together the extended database of the Federal Statistical Office, National Association of the Statutory Health Care Physicians and the German Medical Chamber.

Unlike other areas of modelling, the health care sector is too diversified and patient-specific to be treated as a simple industry (Lillrang et al., p.596). Denton et al. (2009) showed that shortages could be identified only with a specific modelling approach of both market sides and a supply tailored to suit the market needs of medical services. Besides, McRae & Butler (2014, p.271) argue that trends, impact factors or determinants in any physician market can only be understood by the joint consideration of demand and supply.

Within the QuMed research project, a concurrent, comprehensive model considering both, the supply of and the demand for physicians in great detail, has been constructed. It encompasses the whole physician’s market, i.e. the ambulant as well as the in-patient side.

Modelling the entire ambulantory health care sector considering both market sides as well as the in-patient sector provides the opportunity to enhance the planning of the medical market, to identify undesirable trends and to calculate simulations for impact analysis. First results show that the ageing population in Germany urgently requires that the changing healthcare needs of the population are addressed.

The German health care system and the ambulant and in-patient market

The Statutory Health Insurance (SHI) bears 60 % of all current expenditures on health care in Germany (StBA 2016). This includes services from the in-patient sector as well as the ambulatory sector. The ambulatory sector consists of licensed and practice-based SHI doctors, offering not only general medicine but nearly all medical specialities, which can be found in the hospital setting.

In contrast to the widely open access to speciality training after medical school in Germany, the access to the ambulatory (statutory) health care market after specialisation is highly regulated. The Joint Committee (Gemeinsamer Bundesausschuss) regulates the number, type (speciality) and
geographical distribution of medical practices in Germany relying so far on a population based planning method called “Bedarfsplanung” (GBA 2015).

Estimating the demand of the physician workforce only by a physician-to-population ratio would, however, disregard the changing needs of the population. Due to demographic change the German population will not only change in size but also in structure. The number of elderly people continues to increase resulting in a higher average age. There is an accepted positive relation between ageing and per capita demand for physician services (Kuhn & Ochsen 2009, p.2). On the one hand, people are more likely to become ill with increasing age. The demand for ambulant medical services for example, is lowest with a value of 2.3 in the age group of under 20 year old people and stays quite stable at around 2.7 between the patient’s age of 21 and 46 years (StBA 2013, ASHIPs 2014a). Afterwards the demand gradually increases up to 4.4 until the age of 80 years (ibid.). On the other hand, indications for older patients are often different to those of younger people and more often of chronic character, e.g. dementia, adult onset diabetes, cardiovascular disease, musculoskeletal conditions (Heath and Wasson 2008, S.950). The increasing life expectancy adds to the weight of the health needs of elderly people (Cassel 1994). The number and specialisation of physicians should hence be adapted to demographic change. This is a long-term process, because medical doctors undergo a long training, starting with academic studies and ending with medical specialisation. The latter is a necessary precondition for working in the ambulant sector.

The professional career that qualifies for practicing in the ambulant sector as SHI-authorised physician is outlined in Figure 1. The successful completion of the medical education with the receipt of the medical license is followed by a postgraduate training as senior house officer. The area of specialisation is free of choice and takes at least five years training (BÄK, 2013). The duration of the training varies according to the chosen specialisation and possibly can take even longer (ibid.). After the specialisation the physician can apply for a SHI-authorised office (self-employment) or an employment in a SHI-authorised office to become SHI-authorised physician. The availability depends on the current results of the capacity planning and varies with the specialisation and the region. Other career options as specialists are to stay in the in-patient sector with the possibility to become specialist registrar and head of department or to work in the private health care sector. For a specialist, a change between ambulant and in-patient sector is possible any time so that his or her professional career is not clear cut after specialisation.

All physicians are registered in the German Medical Association (Bundesärztekammer, BÄK) via the local State Chamber of Physicians. In 2014, 365,247 physicians were practising in Germany (BÄK 2016a, p.3). The biggest part thereof (51 %) was working in the in-patient sector and 40 % were part of the ambulant sector (BÄK 2016a, p.1). The rest can be assigned to authorities / statutory corporations or other areas (ibid.).

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1 The demand for ambulant medical services is estimated in this context as patients to population ratio. This means that the number of ambulatory patients of one age is divided by the total number of persons in the population of the same age. The number of patients can exceed the number of people in the same age, as people can go to different types of physicians and are counted each time as patient.

2 For the population group 80+ the demand lies at 3.9 patients per population. The lower value does not indicate a better health status but results from the switch to inpatient or care services.
Data and model specification

The data set consists on the one hand of freely available official data from the Federal Statistical Office (StBA), from the German Medical Association (BÄK) and the Central Research Institute of Ambulatory Health Care in Germany (Zi). On the other hand it includes exclusive information: a pseudonymous³ micro-data-set extracted from the federal registry of physicians provided by the National Association of Statutory Health Insurance Physicians (NASHIP) and billing data from the regional Associations of Statutory Health Insurance Physicians (ASHIPs). The data varies with respect to the available data period, but the most recent year for all data files is 2014.

The main data sources for the demand side are the 13th coordinated population projection (StBA 2015a) and the health care statistics (StBA 2015b, 2015c) from the Federal Statistical Office as well as the billing data from the ASHIPs (ASHIPs 2015a, 2015b) and the number of in-patient physicians from the federal registry of physicians (BÄK 2016b). The supply side concentrates on information on the number and structure of physicians (BÄK 2016c, NASHIP 2015), their labour time (Zi 2015, StBA 2012) and their evolution (StBA 2015d).

Figure 2 depicts the model structure. The joint consideration of both market sides was also applied by Birch et al. (2007), Cave et al. (2014) and Denton et al. (1994, 1995, 2009). The modelling routine follows the proposed demand-supply combination of Lillrank et al. (2010). Our supply side model (shown in blue colours) is generated similar to e.g. Basu & Rajbhandary (2004), Cave et al. (2014), Denton et al. (2009) or McClendon (1997) in the sense that a stock-flow-approach is used. The complete professional life of a physician is included. The stock is given by the existing number of physicians registered in the data base of the federal registry of physicians and the German Medical Association. The inflow of medical specialists is estimated considering the number and age structure of students and the composition of the complete group of physicians (ambulant, in-patient and others). The outflow depends on the age structure of the physicians. Changes between both sectors, ambulant and in-patient, are allowed for (given the specialisation condition) and they are used to equalise possible shortages in the ambulant sector. Next to that, behavioural changes of physicians regarding their labour time or kind of employment (self-employed versus salaried) are taken into account as well. Sung-Hee & Hurley (2010, p. 360) emphasised that physician planning models are weak when leaving out such changes.

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³ Pseudonymous means that individual information about each physician is stored in a central database and that the physician identifiers are kept confidential.
The modelling approach regarding demand is more or less the same in most studies with the demographic development being the central driver. As in Cave et al. (2014), Denton et al. (2009), Erhart et al. (2012) or Wille & Erdmann (2011) the demand side (marked in turquoise colours) depends on demographic change. We differentiate between age, sex and indications (choice of medical specialist) of patients. Combining demographic information with billing data collected by the ASHIPs (number of patients and cases treated by 24 different specialists) for the ambulant sector as well as health statistics (Federal Statistical Office) for the in-patient sector the future demand for medical services can be projected. Thus, medical specialties that profit from ageing (e.g. urology) or are faced with a diminishing need (e.g. paediatricians) can be identified.

The complete details of the model methodology are shown in the following sections.

**Supply side of the model QuMed**

The supply side model includes all physicians (ambulant, in-patient and other) but concentrates - due to better data availability - with more detail on the SHI-authorised physicians. That means that the stock and the in- and outflows of SHI-authorised physicians is individually modelled while the remaining number of physicians (all registered physicians minus SHI-authorised physicians) is pooled in a group defined as reserve.

The stock-flow-approach regarding the supply of the ambulant sector (SHI-authorised physicians) works as indicated in Figure 3. The stock of SHI-authorised physicians is distinguished in age, sex and medical specialisation with the age structure and the sex being the main drivers in the projection. The basic stock of each medical specialisation consists of the most current available data set from the federal registry of physicians provided by the National Association of Statutory Health Insurance Physicians (NASHIP). The new stock can be calculated by subtracting from the previous stock the outflow (change in other working areas, e.g. the in-patient sector, switch in specialisation, death,
retirement or emigration) and adding the inflow (completion of postgraduate training, switch in specialisation, immigration, change from other working areas).

**Figure 3: Stock-Flow-Approach of SHI-authorised physicians**

The outflow is estimated for each medical specialisation using specific rates differentiated by 5-year-age groups and sex. The rates represent a (logarithmised) trend determined by the time period from the year 2000 to 2013. The future inflows depend either on the most recent development (2013) or on the median of the period 2007-2013.\(^4\) If the total sum (over sex and age groups) of inflows within a medical specialisation is higher than the total sum of outflows, the actual inflows (differentiated by sex and age) equal the past respective inflows. Or else if the inflows are lower than the outflows within a medical specialisation then the specific inflows are calculated using the last-years inflows combined with the change of the outflows. This approach follows the assumption that practices becoming available normally are taken by successors and inflows hence directly depend on outflows.

The resulting new stock is given in number of persons (differentiated by age and sex). For a better assessment of the related labour supply the stock is converted in BPG\(^5\) and working hours. The translation in BPG is done by a constant factor based on the year 2013. For the conversion in working hours the annual specialisation-specific working time had to be calculated.

In the past, the preferences of labour time have considerably changed in the health-care sector (in-patient and ambulant market). Due to a higher share of female and employed physicians (StBA 2012) the working hours per (self-)employed person diminished from 1.550 in 1991 to 1.392 in 2000 and 1.343 in 2013 (StBA 2015e). Thus, for the projection of the offered labour time the share of self-employed and employed as well as the composition of male and female ambulant physicians have to be considered. The future shares of self-employed SHI-authorised physicians differentiated by specialisation and sex is estimated using a (logarithmised) trend. In combination with the stock of SHI-authorised physicians differentiated by specialisation, age and sex the number of employed and self-employed SHI-authorised physicians can be distinguished. Per capita working hours are based on StBA (2012) and Zi (2015) and are applied to the estimated self-employed and employed SHI-authorised physicians to yield the amount of labour time for each field of specialisation.

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\(^4\) This procedure is necessary due to heavy outliers at the end of the data set. If the outlier is in 2013 the median approach was chosen.

\(^5\) BPG stands for “Bedarfsplanungsgewicht” and is a weighting factor used in “Bedarfsplanung”. The factor can take the value 1.0 / 0.75 / 0.5 / 0.25 and can be interpreted as a kind of Full Time Equivalent. The factor 1.0 represents a physician that can practise full-time, 0.5 one that can practise 50 %-part time etc. The emphasis is on “can” as the value is a legal option. Physicians with 1.0 weights have the right to work full-time, but can also work less.
For the projection of the other physicians pooled in the reserve, the information of the federal registry of physicians (BÄK 2014), the statistics on graduates (StBA 2015f, 2015g) and the expectancy of life (StBA2015d) is used. The data set of the federal registry of physicians (BÄK 2014) consists of summarised data so that inflows and outflows cannot be directly modelled. Instead, the (net) delta, that is the difference between inflows and outflows, is projected depending on the age (separated in less than 40 years and 40 years and older) and added to the stock (see Figure 4). The stock of the reserve for physicians under 40 years considers changes in the number of graduates that are added with a lag of five years. The lag represents the minimum time for the post-graduate specialisation. The other part of the stock with physicians aged 40 years and older is generated including possible switches between the ambulant and remaining sector and the probability of dying. The changes between the reserve and the ambulant health-care sector depend on specific coefficients that reflect the historical switching behaviour for each sex, age and medical specialisation.

Figure 4: Stock-Flow-Approach of reserve

The in-patient supply of physicians as part of the reserve can be separated by using quotas. The data set of the federal registry of physicians divides the overall number of physicians in different groups: those working in (1) the ambulant sector, (2) the in-patient sector and (3) non-practising sectors (e.g. private economy, associations or health insurance). The information is given by medical specialisation, sex and age groups. The reserve consisting of part (2) and (3) is split taking the shares of non-practicing physicians in each age group as constant.

Demand side of the model QuMed
The population is exogenously given by the projection provided by the Federal Statistical Office (StBA 2009). The projection of the German population encompasses time series until 2060 and sets the maximum possible projection horizon of the model. Within QuMed, it determines the age structure and size of the population and is used to project the overall number of patients by sex and age. Generally, the demand side is modelled starting with the number of cases, considering age-specific health needs and frequencies and ending with the overall number of physicians required depending on the specialty.

On the ambulant side (see Figure 5) the number of cases for each of the 24 medical specialities depends a) on the overall number of patients per age and sex in relation to the respective

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6 The graduates are calculated combining estimated first-year students with the probability of successful graduation and average duration of study. The overall number and distribution of male and female students follows a logarithmised trend. The probability for a successful graduation is assumed to remain at the same level as in the year 2013.

7 The 24 medical specialties are: general practitioner, anaesthetist, eye specialist, surgeon, gynaecologist, otorhinolaryngologist, dermatologist, internist, paediatrician, neurologist, orthopaedist, psychotherapist, specialist for radiology, urologist, paediatric psychiatrist, specialist for physical-rehabilitative medicine (PRM),...
population, b) the distribution of the patients per age and sex across the medical specialities and c) the number of visits per year. Demographic change has hence an impact on the overall number of patients, the kind of specialists that are needed and the frequency physicians are visited.

Figure 5: Ambulant demand side of the model

The relationship between patients and population (differentiated by age and sex) is assumed to be constant. For instance, this implies that the probability for patients of each single age to become sick stays the same over time. Hence, with an ageing population, the number of patients will increase: Figure 6 shows that the risk of being ill in a certain age is highest with elderly people (left axis, blue line). The lowest probability of being ill with at least one disease have the 42 to 45-year-olds. Before that in the age of 20 to 42 the value is gradually declining while afterwards, the likelihood of being ill starts to rise again reaching the highest probability for people being 80 years or older. This distribution of sick people according to their age stays almost the same for the available time period from 2009 – 2013 and justifies the rather rigid assumption. Simultaneously, the number of different diseases increases with growing age (right axis, turquoise line).

Figure 6: Probability of being patient with at least one disease (left axis) and probability considering the variety of diseases (right axis) in 2013

The type of diseases for each age and the thus required medical specialists change as well (see Figure 7). While paediatricians for example are almost exclusively visited by young people, urologists have a specialist for nuclear medicine, specialist for radiotherapy, specialist for neurosurgery, specialist for human genetics, laboratory specialist, pathologist, MKG-surgeon, other medical specialities.

8 The maximum number of visits for each medical specialty is four per year, which is due to the survey structure of the billing data. Each patient is registered only once per quarter per medical specialty. This means that if a person goes to one specialists several times in a quarter it is counted only one time. Else if it goes to different specialists it is counted each time. Patients with chronical diseases are thus underrepresented within the data set.

9 The risk of illness is measured by the patients to population ratio, i.e. the number of patients of one age in relation to the population in the same age.
high share of patients aged 60 years and older. The distribution of specialists over the patients (differentiated by age and sex) is assumed to be constant as well. However, this status-quo-assumption is not necessarily valid for all medical specialities. In a future model update this restriction is therefore planned to be relaxed.

Figure 7: Distribution of patients differentiated by age groups over the medical specialities in 2013

Another status-quo assumption is the relation between illness and physician-patient-contact differentiated by sex and age of the patient. This assumption is quite robust and can be validated with the available data. Combining type of patients (by medical speciality) and frequency yields the overall number of cases differentiated by age and sex of the patient and the medical speciality. Given all the assumptions listed, the future number of people by age and sex thus constitutes the number of patients and cases by medical speciality.

In a next step the number of ambulant physicians (in BPG\textsuperscript{10}) needed for the estimated cases are calculated by using the 2013-ratio between cases and physicians for each medical speciality. The hypothesis is that the current number of cases treated in each medical speciality reflects the related maximum service provision. The constant relationship is also used to show future demand under standardised conditions. The unit of BPG is then converted in persons and working time (hours) taking 2013 as reference point. Finally, changes in labour time are integrated based on the results from the supply side (see previous section). As the trend for shorter working hours continues in all medical specialities, the labour-time adjusted demand is higher than the standardised demand.

The above presented modelling approach for the ambulant market also holds in many aspects for the in-patient market. Again, the demographic change serves as a main driver. Starting with the number of cases and the related duration, the total amount of provision and the necessary number of in-

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\textsuperscript{10} BPG stands for “Bedarfsplanungsgewicht” (see footnote 5).
patient physicians can be estimated (see Figure 8). The central status-quo-assumptions concerning distribution and frequency apply as well. The distribution of the population (differentiated by 5-year-age-groups and sex) over the cases differentiated by hospital departments stays the same as in 2013. Hence the special needs of each age group combined with demographic change lead to the changing demand calculated in number of cases for each department. The frequency is represented by the average number of occupation days per case and is standardised based on the value of the year 2013. Cases and average number of occupation days together yield the overall amount of treatment days patients in the in-patient sector will demand.

Figure 8: In-patient demand side of the model

Source: own figure.

One challenge are the differing observation units: the number of cases and the number of occupation days are differentiated by hospital departments, the number of in-patient physicians are structured by the area of the postgraduate training (Weiterbildungsfachgebiet, WBFG). Applying two transition steps, the different units are transferred to the medical specialities of the ambulant market side so that both demand sides can be added and compared.

The first transition is based on the assumption that each hospital department always needs the same combination of physicians with different types of postgraduate training. Additionally, it is assumed that the postgraduate physicians are equally distributed over the hospital units they are working for. The number of physicians differentiated by postgraduate training hence develop as the (combined) demand in the respective hospital units. The second transition is a technical one. It works according to a classification matrix provided by the National Association of Statutory Health Insurance Physicians (NASHIP).

Discussion and Outlook

With the proposed method both market sides can be modelled and a balance between supply and demand can be drawn. Comparing supply and demand helps to determine shortages or sectors with a sufficient number of specialists so that the planning process can be adapted and improved. Moreover, competing relations between ambulant and in-patient sectors for specialists can be detected. First results show that the ambulant supply is in general sufficient to meet the respective demand. Nevertheless, there are some medical specialisations that run the risk of shortages and indicate the need for action. It also becomes apparent that ageing has a considerable impact on the specialisation of physicians required in future.

The weakness of the currently applied modelling approach is that a lot of relations are based on status-quo assumptions: the age-sex rates of utilisation, the per-physician rates of service provision, the group-specific labour time or the probability of graduating to name only a few. For a projection that provides a more realistic picture, the fixed settings would have to be relaxed. Allowing for adjustments that endogenously emerge from the model as often as possible could improve the model outcome. One possibility, for example, would be to model labour supply to be endogenously dependent on income, labour time preferences and the type of employment as proposed by Sunh-Hee & Hurley (2010). The main challenge at the moment is the short time series available (2009-2014). With a growing number of data points more complex methods could be applied.
Further steps would involve scenario analyses. Within these, the impact of demographic change in the light of the current refugee immigration into Germany is one important topic. Due to the high net migration in the past few years, the ageing process of the Germany population is postponed to the years after 2020.\textsuperscript{11} The demand structure for ambulant health-care services will thus be somewhat different to the originally assumed one: a higher number of children will imply more demand for paediatricians. Simultaneously, the number of elderly people still remains high and the demand for urologists will approximately stay the same. Generally speaking, the total demand for medical services will increase with a growing population, but not as fast as with an ageing one.

\textsuperscript{11} Ageing process in this context means that the size of the population is diminishing and the ratio of elderly people (65+) is increasing.
Literature


