Health status of ‘Ruhr-City’ in 2025 – predicted disease burden for the metropolitan Ruhr area in North Rhine-Westphalia

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Background: Demographic change is a driving force of disease burden. The German population is aging and simultaneously shrinking, due to a rising life expectancy and a declining fertility rate. North Rhine-Westphalia (NRW) is the most populous federal state of Germany including the Ruhr metropolitan area. The NRW population is expected to shrink by 2.5% until 2025, the population of the Ruhr area by 9.5%. At the same time, the population forecast predicts a growth of 30% in the age group ≥55 years for NRW. Methods: The ‘burden of disease’ approach of the World Health Organisation (WHO) summarizes the health status of populations. This approach was used to predict the regional disease burden in 2025 by calculating disability adjusted life years (DALY) as the sum of life years lost due to premature death and years lived with disability due to selected diseases. Our projection included selected tumours, myocardial infarction (MI) and dementia. Results: For the Ruhr area, increases in DALYs are expected for all causes studied, i.e. selected tumours (20%), MI (17%) and dementia (36%). The increase in the Ruhr area was estimated to be proportionally lower than in NRW in total, but the disease burden per inhabitant is higher. Conclusion: The population shrinking is no cure for ‘Ruhr City’. The projection of disease burden shows that health status will decrease due to the demographic change. DALY estimates show the potential health gains, which can be won by implementing measures to reduce premature deaths and to prevent new cases.

Keywords: burden of disease, chronic diseases, demographic change, urbanized area, Germany.

Methods

The future burden of disease in NRW was estimated using the population forecast from the Institute of data processing and statistics, the population of NRW is expected to decrease by 2.5% until 2025. Although the total population will shrink, some age groups are expected to grow. Based on this population forecast, by 2025 the group of inhabitants ≥55 years will grow by 30% and that of senior citizens ≥80 years of age by 76%. Age-related and chronic diseases will therefore predominate. The cities comprising the Ruhr metropolitan area face a population loss four times higher (9.5%) than NRW in total. Despite the prognosis that the ‘Ruhr City’ area will lose almost 10% of its actual population, the effects of demographic change might result in higher burden of disease. Starting with three disease groups, we show that by zooming into regions the burden of disease approach can be used to detect the regional future health gaps and to show the potential health gains. Looking at estimates for 2025 there is still time to implement adequate health policies.

Introduction

Population-based prevention aims at decreasing the prevalence of the most common and severe diseases like cardiovascular diseases, diabetes mellitus type II, cancer and dementia. The aim is to improve population health. In order to develop prevention measures, information about the expected future burden of disease is important base line knowledge. The ‘burden of disease’ approach of the World Health Organisation (WHO) is one method to summarize the health (or disease) status of a population. The WHO used this approach to compare disease burden globally and to predict mortality and disability by disease worldwide. In some countries, in addition to these Global Burden of Disease (GBD) studies the method was adapted to measure population health on national or regional level.

The demographic change is one important driving force of the total burden of disease in a population. The population of Germany is aging and simultaneously shrinking, due to an increasing life expectancy and a declining fertility rate. North Rhine-Westphalia (NRW) today is the most populous federal state of Germany. NRW, which comprises 54 regional administrative units (31 counties and 23 cities), has 18 million inhabitants. Of these, 5.3 million citizens live in the Ruhr area (4 counties, 11 cities). Therefore, the Ruhr area represents the largest urbanized, most densely populated region of NRW. According to the prognosis of the NRW Institute of data processing and statistics, the population of NRW is expected to decrease by 2.5% until 2025. Although the total population will shrink, some age groups are expected to grow. Based on this population forecast, by 2025 the group of inhabitants ≥55 years will grow by 30% and that of senior citizens ≥80 years of age by 76%. Age-related and chronic diseases will therefore predominate.

The cities comprising the Ruhr metropolitan area face a population loss four times higher (9.5%) than NRW in total. Despite the prognosis that the ‘Ruhr City’ area will lose almost 10% of its actual population, the effects of demographic change might result in higher burden of disease. Starting with three disease groups, we show that by zooming into regions the burden of disease approach can be used to detect the regional future health gaps and to show the potential health gains. Looking at estimates for 2025 there is still time to implement adequate health policies.
for NRW in total and for the Ruhr area, this calculated life table provided the basis for the disease burden estimates for both NRW (total) and the Ruhr area.

The burden of disease was calculated in disability adjusted life years (DALY) adapting the methodology of the GBD. DALY estimates are counting years of life lost (YLL) due to premature death caused by various diseases and years lived with disability (YLD) due to these selected diseases. One DALY represents the loss of the equivalent of 1 year of full health. This summary measure allows the comparison of diseases causing premature death (e.g. specific cancers) with diseases that do not cause proximate death but disability (e.g. dementia). This measure also allows comparing burden of disease between regions.

The first step was to prioritize the diseases to be included in the regional analysis. Cancer, cardiovascular disease and dementia are more prevalent in older age groups. In Germany, most deaths are caused by coronary heart diseases followed by cancer. Dementia already affects 1 million people in Germany. Of these persons, 20% are living in NRW. Two-thirds of the cases occur in persons older than 80 years of age. Since this age group is increasing heavily in NRW and ‘Ruhr City’, we have chosen these diseases for our first comparative projection.

In order to identify the most relevant tumour sites, the proportion contributed by each site to the total of cancer deaths was used. According to this ranking, we selected eight tumour sites (lung, colon, rectum, pancreas, stomach, prostate, breast, ovary). For coronary heart disease, our analysis was restricted to myocardial infarction (MI), because only for this diagnosis the necessary accurate, validated, and complete registry data were available.

The YLL due to premature death caused by these selected cancer sites and MI were estimated using death rates by age group and sex obtained from the cause of death statistic of the federal state of North Rhine–Westphalia. As in the GBD study, we applied a standard life expectancy at birth set at 80 years for men and 82.5 years for women.

The YLD due to selected cancers, MI, and dementia were estimated using incidence data from the epidemiological cancer registry of NRW, the MI registry of the German KORA study, and the results of the meta-analysis on incidence and prevalence of dementia by Bickel (2000). The WHO weights for Western Europe (Euro A) were used for disability weighting.

For our prognosis, incidence and mortality rates were assumed to remain consistent. Incidence rates and mortality were given separately by ICD 10 codes, so in the following colon and rectum are presented separately. For the duration of life time with the selected diseases, we used the DISMOD II software provided by the WHO. As basis for this DISMOD application, we used the relative survival rates documented by the national cancer documentation centre at the Robert Koch-Institute (5-year survival times in percentage of patients by sex). Relative survival rates, absolute mortality rate for the regions and relative mortality rates were used to calculate remissions rates (by age group and sex), which served as one parameter for DISMOD. For MI, the KORA infarction registry provided age specific information on lethality. For dementia, there is an ongoing discussion if dementia is the main cause of death. For this comparative projection, we decided to present YLD only for dementia.

Results

According to the population projection, by 2025 life expectancy for newborns in the federal state of NRW is expected to rise by 2 years compared with the 2003/2005 life table (table 1). At the same time, in the most populous area--the metropolitan ‘Ruhr City’--a population loss of >20% in the age group of children and young adults is predicted for 2025, and the working-age group (35–54 years) is expected to shrink by almost 30%. The older age groups, however, are predicted to grow in both regions, NRW in total and the Ruhr area. Table 1 shows the demographic parameters for NRW in total and for the Ruhr area.

Aging of the population in the Ruhr area is predicted to proceed slightly faster. In 2025, 48% (18%) of its inhabitants are expected to be ≥50 (≥80) years vs. 46% (17%) in NRW.

### Proportional increase in cancer differentiated by region

The predicted estimates for incident cases due to the selected tumour sites show that health care facilities in NRW should be prepared to treat approximately 10,000 additional male cases and 4500 additional female cases in 2025 compared with today. Of these, approximately 2200 male and 650 female cases are expected to live in the Ruhr area. Thus, the average increase in incidence to these selected sites in NRW is expected to be 34% in men and 20% in women. In the Ruhr area, the incident cases are predicted to rise by 23% (men), respectively 10% (women; figure 1).

Based on this increase in incident cases, the total sum of YLD due to these cancers will rise by 20% in NRW. According to our estimates in NRW, the sum of YLDs will rise from 57,208 (2004, both sexes) to 68,817 (2025). In the Ruhr area, an increase of 10% is likely (YLD for both sexes in 2004: 17,026; in 2025: 18,728).

In 2004, the YLL to premature death due to these cancers accumulated to 283,417 YLL for NRW. Of these 93,800 YLL (33%) are expected to occur in the Ruhr area. For the year 2025, our prognosis predicts 380,968 YLL in NRW and 114,374 YLL in the Ruhr area, resulting in a relative increase of 34% (NRW) and 22% (Ruhr area).

Hence, an increase of 31% of DALY due to the selected tumour sites is expected for NRW in 2025 (2004: 342,625 vs. 2025: 449,485). For the Ruhr area, we found an increase of 20% in DALYs (2004: 110,826 vs. 2025: 133,102).
Both regions NRW and Ruhr area (Figure 2). The increase in DALYs (>300%) for the age group of men/C21 differs by age group. This prognosis shows a dramatic that the DALYs will rise by 35% till 2025. However, the predicted to rise by 35% in persons 60 and by 28% in women/C21. In 2025, there will be still twice as much DALYs due to dementia. Additional DALYs of 34% are predicted due to new female dementia patients than due to males (2025: men 35 554; women 76 115; ratio 1:2.1).

**Change in disease burden due to MI**

A total of approximately 10 000 incident infarctions is expected for the Ruhr area in 2025 (men: 5946; women: 4112). Additional acute MI are estimated as 1185 events in men ≥30, and 672 additional events in women ≥30 compared with 2004. The patients ≥85 years will represent a proportion of 19% in men (2004: 7%) and 37% in women (2004: 24%).

Compared with 2004, the number of events in this age group is predicted to rise about 246% (2004: 322 vs. 2025: 1116) in men and 86% in women (2004: 697 vs. 2025: 1512). MI mortality is expected to rise by 35% in persons ≥30 in the Ruhr area (men: 42%; women: 28%).

The increase over time in DALYs due to MI is predicted to be 16% (men: 24%; women: 8%). For NRW, we estimated that the DALYs will rise by 35% till 2025. However, the increase differs by age group. This prognosis shows a dramatic increase in DALYs (>300%) for the age group of men ≥85 in both regions NRW and Ruhr area (Figure 2).

**Proportional increase in dementia highest in relation to selected cancers and MI**

In people ≥80 years, the prevalence of dementia exceeds the level of 10%. Three percentage of this age group are newly diagnosed per year. The estimates show that in NRW the number of incident cases ≥80 will have increased by approximately 20 000 in 2025. Of these new cases, 30% are expected to live in the Ruhr area. In younger age groups, the prevalence was observed in the range of 0.1% (30–59 years/C21) to 5.9% (75–79 years/C21). In our estimate for 2025, a total of 363 729 prevalent cases is predicted for NRW. This means a proportional increase in DALYs (>300%) for the age group of men ≥85 in both regions NRW and Ruhr area (Figure 2).

**Disease burden per inhabitant**

The cancer mortality burden (YLL) due to the tumour sites of lung, colon, rectum, pancreas and stomach (Table 1) was estimated to be higher in men than in women, whereas the disability burden (YLD) due to these cancers is similar for both. For MI (Table 2), the incidence and mortality rates resulted in a higher burden in men in both dimensions, YLL as well as YLD. The estimates for dementia show a higher disability burden in women (Table 2).

According to our comparative projection of NRW vs. its most populous area (Ruhr), the relative increase from 2004 to 2025 is lower for all three observed disease entities (cancer, MI, dementia) in the Ruhr area, although this is more than outweighed by the disease burden per inhabitant. In cancer, in MI, and in dementia all DALY base line estimates per 1 million inhabitants (2004) are higher in the Ruhr area already, either in men or women (Table 2). The proportional differences in estimated rates will remain similar in 2025, but the different course of the demographic change in some age groups (Table 1) will have narrowed the gap by almost 2% in cancer. In MI, we found the highest proportional difference in DALYs between NRW and the Ruhr area in 2004: 36% in women (Table 2). In 2025, it will probably be only 16% (Table 2). For dementia, the opposite was seen: the proportional difference in DALYs per 1 million inhabitants will increase (women: 27% in 2004; 31% in 2025).

**Discussion**

Our projection shows, that the burden of disease will increase in NRW and in the metropolitan Ruhr area. However, the difference between the estimates of the relative increases in incident cancer cases in NRW and in the Ruhr area is obvious. First, this is due to a higher population loss in the Ruhr area (9.5% vs. 2.5%), especially in women. Second, the population growth in the older age group which corresponds to the average age at first diagnosis (for cancer in Germany: 69 years), is ~10% lower in the Ruhr area (Table 1). In males aged 80–84, the proportional growth is expected to reach 14% in NRW and ~3% in the Ruhr area. In women aged 75–79, a population loss of 14% is expected in the Ruhr area, but only 4%
for NRW. Hence, a smaller relative rise of DALYs was found for the Ruhr area. However, the lower relative increase of DALY by 2025 is no all-clear for the health care system in the Ruhr area. As table 2 shows, the burden of disease in this area is higher already today. Therefore, even the comparatively lower increase does not mean smaller problems in health care. The DALY rates are 5–30% higher in the Ruhr area for all examined diseases.

The different development for disease burden of cancer and dementia in women (table 2) is due to the age of first diagnosis of these diseases. In the Ruhr area, the shrinking of the female population aged 35–54 is stronger than in NRW (table 1), contributing to a decreasing number of cancer cases. The age group of women 80+ will grow further resulting in more cases of dementia.

This situation in the Ruhr area may be due to the fact, that 5 out of 11 cities represent socially deprived regions.
The number of avoidable deaths due to ischaemic heart disease, liver diseases, hypertension, as well as infant mortality and the proportion of underweight newborns are higher in this ‘poverty pole’ than in the other cities or municipalities of the Ruhr area or in NRW in total.29 These findings of higher disease burden in this partially deprived area are consistent with the results of an Australian study. Mathers and co-authors7 found that the most disadvantaged quintile of the Australian population lost 35% more years of life than the least disadvantaged quintile. For Australians <65 years of age, the differential burden between the lowest and highest quintile was even higher, with a 60% excess burden in the most disadvantaged group.

An analysis of the age- and sex-specific mortality in the Ruhr area showed an increased mortality from 1994 to 2004, especially for people aged 40–54 years. A comparison of Bonn (the city representing the highest life expectancy level in NRW) with Gelsenkirchen (having the lowest life expectancy level in NRW, and part of the ‘poverty pole’ in the Ruhr area) showed a difference of 2.7 years in females and 4.3 in males in life expectancy (2002–04). The mortality rate of the age groups 40–59 years in Gelsenkirchen exceeded the rate in Bonn by 30%.30

Richter et al.31 showed that in NRW the non-participation in cancer screening programmes increased with decreasing social class. For the general health check-up the authors found no socio-economic differences. The recently published British Women’s Heart and Health Study32 reported similar findings. The authors observed that British blue-collar women were less likely to have recent influenza vaccinations [odds ratio (OR) 0.85, 95% confidence interval (CI) 0.74–0.98] and dental (OR 0.42, 95% CI 0.36–0.49) or eye examinations (OR 0.77, 95% CI 0.67–0.88). Assuming prevention, early diagnosis and cancer screening are measures to reduce disease burden, more socially and educationally specific measures are needed to promote those programmes.

In NRW, 22.5% of the inhabitants have an immigrant background, mostly Turkish. Forecasts of future migration into NRW from foreign countries and of the number of persons migrating back to their home country remain uncertain. This is one factor limiting the accuracy of our prognosis of disease burden.

Our estimates for future burden of disease are based on current incidence and mortality rates of the investigated diseases. We did not include assumptions about changes in incidence, duration of the selected diseases or disability weights. The accuracy of our estimates is limited since we only calculated the impact of the demographic effect. Demographic changes and changes in incidence or mortality are not the only parameters that may influence the number of DALYs. For example, a smaller duration will make DALYs decrease even with the same demographic structure and similar mortality and incidence rates. All estimates for NRW include the Ruhr area. If estimates were calculated for NRW without the Ruhr area, the differences in burden might be even higher. Since cancer registration in NRW was limited to the administrative district of Münster (population: 2.6 million) until 2005, incidence and DALYs might have been

| Table 2 Cancer, myocardial infarction and dementia, comparison of changes in estimates of incidence, mortality and burden of disease 2004 vs. 2025 |
|---|---|---|---|---|---|---|---|---|
| | Selected tumours | NRW | Metropolitan Ruhr area |  |
| | | Men | Women | | Men | Women |  |
| Estimated rates per 1 million inhabitants | 2004 | 2025 | 2004 | 2025 | 2004 | 2025 | 2004 | 2025 |
| Selected tumours, men/women (lung, colon, rectum, pancreas, stomach) | | | | | | | | |
| Incident cases | 1970 | 2710 | 1350 | 1690 | 2100 | 2850 | 1430 | 1770 |
| YLDa | 1660 | 2170 | 1620 | 1900 | 1650 | 2100 | 1610 | 1890 |
| Mortality (deaths) | 1480 | 2120 | 950 | 1220 | 1690 | 2370 | 1050 | 1360 |
| YLLb | 14160 | 20020 | 8860 | 11630 | 16330 | 22670 | 9920 | 12760 |
| DALYc | 15820 | 22190 | 10470 | 13530 | 17980 | 24760 | 11540 | 14640 |
| Prostate cancer, men only |  | | | | | | | |
| Incident cases | 1350 | 1880 | 1430 | 1960 | 1350 | 1880 | 1430 | 1960 |
| YLDa | 1660 | 2170 | 1650 | 2100 | 1650 | 2100 | 1650 | 2100 |
| Mortality (deaths) | 290 | 530 | 310 | 540 | 290 | 530 | 310 | 540 |
| YLLb | 2040 | 3570 | 2180 | 3680 | 2040 | 3570 | 2180 | 3680 |
| DALYc | 3700 | 5750 | 3870 | 5880 | 3700 | 5750 | 3870 | 5880 |
| Breast cancer and ovary cancer, women only |  | | | | | | | |
| Incident cases | 1440 | 2780 | 1440 | 2780 | 1440 | 2780 | 1440 | 2780 |
| YLDa | 1390 | 1550 | 1390 | 1550 | 1390 | 1550 | 1390 | 1550 |
| Mortality (deaths) | 580 | 730 | 580 | 730 | 580 | 730 | 580 | 730 |
| YLLb | 6470 | 8060 | 6470 | 8060 | 6470 | 8060 | 6470 | 8060 |
| DALYc | 7870 | 9610 | 7870 | 9610 | 7870 | 9610 | 7870 | 9610 |
| Myocardial infarction |  | | | | | | | |
| Incident cases | 1640 | 2320 | 1070 | 1430 | 1870 | 2570 | 1260 | 1660 |
| YLDa | 5110 | 6320 | 2550 | 3080 | 5580 | 6970 | 4180 | 3420 |
| Mortality | 880 | 1420 | 730 | 1050 | 990 | 1560 | 860 | 1210 |
| YLLb | 7790 | 11600 | 5000 | 7400 | 8920 | 12920 | 6100 | 8760 |
| DALYc | 12910 | 17920 | 7550 | 10480 | 14510 | 19890 | 10280 | 12180 |
| Dementia |  | | | | | | | |
| Incident cases | 1440 | 2780 | 1440 | 2780 | 1440 | 2780 | 1440 | 2780 |
| YLDa | 8300 | 14150 | 8300 | 14150 | 8300 | 14150 | 8300 | 14150 |
| Mortality | 8300 | 14150 | 8300 | 14150 | 8300 | 14150 | 8300 | 14150 |
| DALYc | 8300 | 14150 | 8300 | 14150 | 8300 | 14150 | 8300 | 14150 |

a: Years lived with disability (YLD)
b: Years of life lost (YLL)
c: Disability adjusted life years (DALY)
underestimated. The district of Münster is wealthier and is less populated and urbanized than ‘Ruhr-City’. The same limitation in accuracy is true for MI since the registry does not assess data in NRW, but in the federal state of Bavaria.

Fendrich and Hoffmann calculated incident cases due to MI and prevalent dementia cases for the German federal state of Mecklenburg-West Pomerania in 2020 using the same data sources for incidence of MI and prevalence rates of dementia as we did. For MI, the authors predicted an increase of 41% (all age groups) from 2002 to 2020. In comparison, we projected a similar increase of 36% of incident cases from 2004 to 2025 for NRW. Estimates differ when restricted to the incident cases of persons ≥70 years. In this age group, the expected increase is 83% for Mecklenburg-West Pomerania and 55% for NRW. This difference is caused by regional variation in demographic change. Fendrich and Hoffmann reported a predicted relative proportion of 27% (13%) of persons ≥65 (≥75) in 2020. In NRW, this relative proportion is only 24% (12%) in 2025. In dementia, an increase of prevalent cases of 67% is expected for Mecklenburg-West Pomerania. For NRW, we estimated an increase of 58%.

This study is a start in identifying specific regional health gaps by regional projections of disease burden. Mortality and disability burden are specific for age groups and sex, and vary within states as our estimates show. The increase in burden of disease due to growing of older age groups until 2025 shows, that especially in specific regions there is a high potential for prevention to reduce age-related disease (compression of morbidity), for increase of quality in life years with disability, and for gaining more disability-free life years.

Conclusions

According to these rising estimates of disease burden in old age, there is a strong need for improving prevention and early diagnosis in order to reduce at least some of the future burden of disease. These results will help to begin preparing health care for a growing number of very old patients. Therapies need to take greater consideration of elderly patients. More information and education on treating geriatric patients should be offered to practitioners and hospitals in the Ruhr area to maintain today’s high standard of medical care for all citizens.

Because of its socio-demographic characteristics and the health care challenges due to the shrinking and aging urban population, the metropolitan Ruhr area might serve as a model for solutions for other regions in Europe, too.

Conflicts of interest: None declared.

Key points

- We investigated the effects of the demographic change on burden of disease due to selected chronic diseases with onset predominantly at advanced age (cancer, MI and dementia) in the metropolitan Ruhr area vs. NRW.
- Our projection shows that in 2025, the impact of the demographic change means an increase in DALY due to premature death and YLD, especially in men of very old age due to MI.
- According to our projection, the demographic factor will tighten the situation of population health in the metropolitan Ruhr area, where the burden of disease is already comparatively high.

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