Future disease-specific health spending and burden of disease in Norway, 2019 to 2040

JONAS MINET KINGE[1, 2 *]
SØREN TOKSVIG KLITKOU[3]
HENNING ØIEN[1, 2]

[1] Department of health management and health economics, University of Oslo, Oslo, Norway
[2] Norwegian Institute of Public Health, Oslo, Norway
[3] MSD Norway, Oslo, Norway

Abstract: The expected increase in the proportion of elderly, coupled with increasing rates of chronic diseases, presents a challenge to the Norwegian healthcare system. In this study, we project the future burden of disease and health spending for various health conditions from 2019 to 2040; and explore the importance of: 1) population growth, 2) population composition, and 3) future epidemiological development for these projections. We find that total and per capita, health spending are projected to increase in three scenarios (reference, better and worse health) from 2020 to 2040 for communicable diseases, non-communicable diseases, and injuries. The increased proportion of elderly drives the increase in health spending. When keeping the age composition constant (thereby accounting for the increased proportion of elderly), we find that per capita health spending decreases in the reference and better health scenario but not in the worse-health scenario. If Norway aims to provide care at current levels in the future, substantial reductions in the cost of care combined with increased productivity is needed. Most likely combined with, increased health spendinge, due to chronic conditions in old age.

JEL classification: H51, I19

Keywords: forecasting, burden of disease, health care cost, ageing population

1 Introduction

Global health expenditures are growing and are expected to double by 2050 (Micah et al., 2021). This growth is spurred by increasing rates of chronic diseases associated with aging populations. As a result, nations must plan how to handle the growth in health spending. They will be forced to consider measures of cost containment, productivity growth and likely in combination increased health spending, to secure the financial sustainability of their health systems.

Health expenditure projections can help countries in this planning by providing information on how quickly and by how much health expenditures are projected to rise under different scenarios (Lorenzoni et al., 2019).

*** *Correspondence to:*** Jonas Minet Kinge, Department of health management and health economics, University of Oslo, Oslo, Norway. Email: j.m.kinge@medisin.uio.no.
Published: Online December 2023. dx.doi.org/10.5617/njhe.10188

In this study, we aim to project the future burden of disease and health spending by health conditions from 2019 to 2040; and to explore the importance of population growth, population composition, and future epidemiological development, for these projections. More specifically, we:

1. Aim to project the future epidemiological development in terms of DALYs (a summary measure of health-related quality of life and mortality) and use these projected DALYs to project future disease-specific spending.
2. Explore the consequences of future population size and population composition.
3. Study the impact of future epidemiological development on projected spending using projected DALYs. We also include two alternative scenarios (better health and worse health), which vary future disease-specific DALYs.

We find that total, and per capita, health spending is projected to increase in each scenario (reference, better and worse health) from 2020 to 2040 for communicable diseases, non-communicable diseases, and injuries. The increased proportion of the elderly drives the increase in health spending. When keeping the age composition constant (and by this account for the increased proportion of elderly), we find that per capita health spending decreases in the reference and better health scenario but not in the worse-health scenario.

1.1 Approaches to forecasting health spending

A voluminous literature forecasts future health spending, either at the aggregate level or disaggregated by type of care (like inpatient and primary care). Astolfi et al. (2012) divide this literature into three classes of forecasting models. The first is microsimulation models, which use individuals as the unit of analysis, but can be aggregated to reflect total health spending. Microsimulation models are particularly powerful for analyzing the consequences of interventions. The second is macro models, which use time-series models to forecast health spending based on, e.g., past GDP growth and inflation rates (Getzen and Poullier, 1992). These models are most useful for short-run forecasts (Astolfi et al., 2012).

The final and most common category of models is accounting/actuarial-based models. In these models, the population is divided into groups and linked to the average cost within those groups. Then the sum of the future number in each group times the annual health spending is calculated. Most often, age and sex are used to form the groups and some accounting models implicitly assume that health status and disease prevalence will remain fixed in relation to age and sex.

A challenge in these accounting models is that a population’s need for health care depends not only on the size and age composition, but also on the prevalence of diseases and their associated disability (Lee and Miller, 2002). Hence, there exist various attempts to project health status in the future. For example, Manton (2005) constructs models for health status as a function of demographic characteristics, lifestyle behaviors, and risk factors. Singer and Manton (1998) projected broad measures of disability in the population and used this to forecast health care spending (Singer and Manton, 1998). Lee and Miller (2002) derive the association between health spending and age from the relationship between age and the fraction of people who are close to death and use this relation in their forecast models (Lee and Miller, 2002, Fuchs, 1984).

Our study uses information about disease-specific prevalence and disability directly in the forecast models. The approach is comparable to two Australian studies, which forecast the prevalence and incidence of diseases and use age-sex forecasts from the Australian Bureau of Statistics (Vos et al., 2007, Goss, 2008). They then associate the per age-sex-disease case cost with the projected number in those age-sex-disease groups.

2 Methods and data

In this study, we use data from the global burden of disease project, population forecasts by Statistics Norway, and spending data from the Norwegian Health Spending Study (Kinge et al., 2023). In the following sub-sections, we explain the three data sources.

2.1 Global burden of disease

Epidemiological data, which are used as input in our model, are from the global burden of disease project (GBD). We extract data on disease burden metrics, by disease and age, from 1990 to 2019 and forecasted disease-specific mortality from 2019 to 2040.

The GBD provides regular summaries of the combined burden from early death and time lived with the disease for several diseases and injuries. The main measures of disease burden are, the number of years of life lost (YLLs) and the number of years lived with disease (YLDs), which are combined into a summary measure called disability-adjusted life years (DALYs). DALYs are a summary measure capturing the effect of both mortality and non-fatal health loss in a given year and can be interpreted as years of healthy life lost to diseases (Murray et al., 2013).

In estimating these quantities, YLLs are computed by multiplying the deaths at each age x by a standard life expectancy at age x, using a reference life table. The standard selected represents the normative goal for survival, and the reference life table is computed based on the lowest recorded age-specific death rates across countries in 2019. YLDs are computed as the prevalence of different diseases and injuries multiplied by the disability weight for that disease or injury. Disability weights were determined in surveys of the general population about the loss of health associated with the health state related to the disease or injury (Salomon et al., 2012, Salomon et al., 2015).

The estimates for Norway from the GBD2019 database are based on a combination of Norwegian registry data, health surveys, and published studies. The Norwegian prevalence estimates are also constructed from non-Norwegian data. The estimates were calculated in a model in the following order: global, region, and country (Norway). Data for all countries are used to provide global estimates of disease burden. The data for each region is used to estimate regional disease burden. Finally, estimates for each country are used to estimate each country's disease burden. If the data for a specific disease is of high quality, the country's estimate will be almost solely based on country-specific data. However, if data is of poor quality or lacking, the estimates will be based on the regional and global data (GBD2019 collaborators, 2020).

Previously, the GBD has published a forecast of the future burden of years of life lost (Foreman et al., 2018). The reference forecast through 2040 was based on modeling inputs including ten health scenarios in 2040 by location, risk factors, select public interventions such as vaccines and preventive health measures[1], income per person, educational attainment, and total fertility rate under 25 years. In addition, they presented two alternative scenarios: better and worse health. The better health and worse health scenarios for each disease category, reflecting the 85th and 15th percentiles of annualized rates of change of the above modeling inputs, respectively, reflect the scope of the policy change (Foreman et al., 2018). Of the risk factors entering as modeling inputs, it is smoking (#1), high body-mass index, alcohol use, high blood pressure, and high blood sugar levels (#5) that lead in importance for the difference between projected health scenarios (Appendix

[1] Interventions quantified in GBD currently include antiretroviral therapy (ART) for people living with HIV, prevention of mother-to-child transmission of HIV, met need for family planning with modern contraception methods, and vaccination coverage of diphtheria, tetanus, pertussis, (three doses) and measles; pneumococcal conjugate vaccine; and vaccination coverage of rotavirus; and Haemophilus influenzae type B.

Table 1). This forecast lacks the YLD component of DALYs; hence, we add this as explained below.

2.2 Future population counts

From Statistics Norway we extract data from scenarios of future population counts by age (Thomas and Tømmerås, 2022). This article employs the "primary model," which assumes middle changes in future immigration, fertility, and mortality (Thomas and Tømmerås, 2022). The primary model is considered the most likely scenario of future population growth and is typically used in the discourse on public policy and the future need for health (and social) services in Norway (Thomas and Tømmerås, 2022).

In the most recent forecast from 2022, fertility is forecasted to drop (-0.05) from current levels to 1.5 until 2025 and stabilize at 1.7 children per woman with low and high scenarios of 1.3 to 1.9 children per woman. Similarly, mortality is projected to drop over the 21st century, with the life expectancy of men (women) reaching 85.6 (88.1) years in 2040, with low and high estimates of 87 (89.4) and 83.9 (86.7) years, up from 81.6 (84.7) years in 2021. Yearly net immigration is by Statistics Norway forecasted to be 12 thousand, with low and high estimates of 5-22 thousand net yearly immigrants in 2040, up from 20 thousand in 2021. Our results are from the middle forecast for fertility, immigration, and mortality.

2.3 Health spending

Data on health service spending is taken from the Norwegian Health Spending Study government budgets, government documents, reimbursement databases, patient registries, and prescription databases were combined to estimate spending for health conditions, age, sex, and five types of care (ambulatory, inpatient, nursing care facility, home-based care, and prescribed pharmaceuticals purchased in a retail setting) (Kinge et al., 2023).

The process used to generate spending estimates by payer was based on methods previously developed by the Institute for Health Metrics and Evaluations for the Disease Expenditure Project (DEX) (Dieleman et al., 2016, Dieleman et al., 2020, Kinge et al., 2017). The process can be divided into three steps. First, health condition was assigned to each encounter and its associated unit cost based on available disease codes in each data source. Second, the estimates were adjusted for data gaps, imperfections, and comorbidities. Third, the estimated spending from the microdata was scaled to reflect the official Norwegian spending in the Norwegian National Health Accounts (Statistics Norway, 2021).

The data reflected ≈80% of health care spending in Norwegian National Health Accounts in 2019. Excluded from this study were dental health care; durable medical equipment and non-durable medical products, which include over-the-counter medicines; preventive care providers, health system administration and health care in other industries.

2.4 Statistical methods

We first project DALYs, which are then used in an accounting model for health expenditures. The accounting model sums the number of people in each health/age group times the annual spending associated with that health/age group.

To project future DALYs, we combine the forecasted rates of YLLs until 2040 with the relationship of YLLs to DALYs as they were in 2019 and compute a future projected rate of DALYs per 100,000 population from the following relation,

$$(1) \qquad DALY\ rate_{\mathrm{d},\,y,a} = Forecasted\ rate\ of\ YLLs\ _{d,y,a}\ \ / \ \ \frac{\text{YLL rate }2019_{d,a}}{\text{DALY rate }2019_{d,a}}\ ,$$

where *a* represents age in 5-year age categories (< 5, 5-9, …, 85+ years), *y* represents the years 2020-2040, and *d* represents the disease categories of interest. These rates are then given per person time and need to be combined with future population figures to give the headcount of future DALYs using the following relation:

$$(2) \quad DALYs_{d,y,a} = DALY\ rate_{\mathrm{d},\,y,a} \times \text{ population counts}_{y,\,a}$$

We interpret these counts of DALYs as the forecasted future ill health from GBD when current relations of mortality (YLLs) to the prevalence of disease (YLDs) remain as they were in 2019.

The projected health spending in 2020-2040 is calculated as the spending rate multiplied by the population number by age group:

$$(3) \quad Health\ spending_{d,y,a} = \left(\frac{Spending\ per\ capita\ 2019_{d,a}}{DALY\ rate\ 2019_{\mathrm{d},a}} \times DALY\ rate_{\mathrm{d},\,y,a}\right) \times \text{ population counts}_{y,\,a}$$

Hence, the spending per age by health conditions category varies with the projected DALY rate per health condition category. We interpret this spending as the projected health spending when current relations of DALYs to health spending remain as they were in 2019 at future population size scenarios. The health spending estimates are measured in real 2019 Norwegian kroner.

In the first projection, disease categories (*d*) are divided into three categories: 1. communicable, neonatal, maternal, and nutritional; 2. non-communicable; and 3. injuries. We use the reference scenario as the baseline but also provide results estimated based on the GBD scenarios of better and worse health. These scenarios are explained in more detail in section 2.1.

Finally, we estimate models with eight disease categories: cardiovascular disease; cancer; injuries; mental disorders; musculoskeletal disorders; neurological disorders; diabetes, urinary & endocrine; and a combined category for other causes.

The DALYs are projected based on mortality forecasts, and there are few deaths directly from mental and musculoskeletal disorders. We, therefore, project mental, and musculoskeletal disorder spending based on age only:

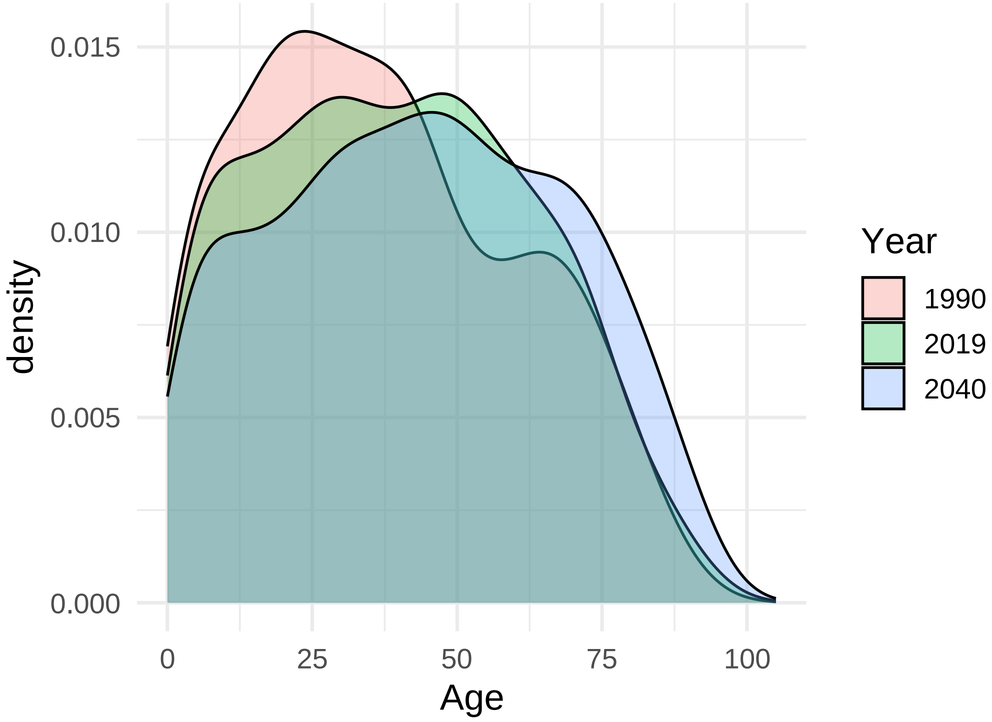
$$(4) \quad Health\ spending_{dS,y,a} = Spending\ per\ capita\ 2019_{dS,a} \times \text{ population counts}_{y,\,a}$$

With *dS* representing the causes of mental health and musculoskeletal disorders.

3 Results

In Figure 1, we plot overlapping densities of the age distributions of the Norwegian population in 1990 and 2019 and the projected population distribution in 2040. We observe a shift in the age distribution over time. The shares of younger age groups are falling over time, while the shares of older age groups are increasing. In Appendix Figure 1, we illustrate the population aging by plotting the share of the population in the age groups younger than 20, between 20 and 64, between 65 and 84, and older than 85. The population above age 84 is projected to increase from roughly 2% in 2019 to roughly 4.4% in 2040.

Figure 1: Norwegian population distribution by age in 1990, 2019 and 2040.



DALYs are projected to increase in each scenario (reference, better and worse) and for each of the three disease categories from 2020 to 2040 (Figure 2, panel A). Adjusting for the population size did not fully offset this increase (Figure 2, panel B). However, removing aging through age-standardized projections demonstrates reduced DALYs per 100,000 persons (Figure 2, panel C). Hence, although the number of DALYs is projected to rise over time (because of an aging and growing population), the age-standardized rate of disease decreases.

In Figure 2, especially for non-communicable (middle column) and injuries (rightmost column), we see that the number of DALYs has sharply increased from 2015. This is because of the sharp increase in the share of the population in the oldest age groups from 2015, as is demonstrated in the right column in Appendix Figure 1.

Total health spending is also projected to increase in each scenario (reference, better and worse) from 2020 to 2040 for communicable diseases, non-communicable diseases, and injuries (Figure 3, panel A). Adjusting for the population size did not offset this increase (Figure 3, panel B). However, removing aging through age-standardized projections demonstrates reduced health spending per 100,000 persons (Figure 3, panel C). However, this result only materialized in the reference and the better-health scenarios, but not in the worse-health scenarios.

In the left panel of Figure 4, we present the projected number of DALYs and total health spending for eight disease categories from 2020 to 2040. Disease burden, measured in DALYs, is dominated by “other diseases,” neoplasms and mental disorders. These disorders are likely to dominate in the future too. Burden from CVDs will continue to be high, though their burden is not projected to increase as steeply as the other disorders. A corresponding picture is observed for disease-specific spending, though their composition differs (Figure 4, right panel). Neurological disorders -which contain Alzheimer’s and other dementias- will increase substantially and becomes the most expensive category before

2040. We also observe a sharp increase in spending on DUE (diabetes, urinary and endocrine diseases) from 2020 to 2040.

Figure 2: Historical and future DALYs, 1990-2040.

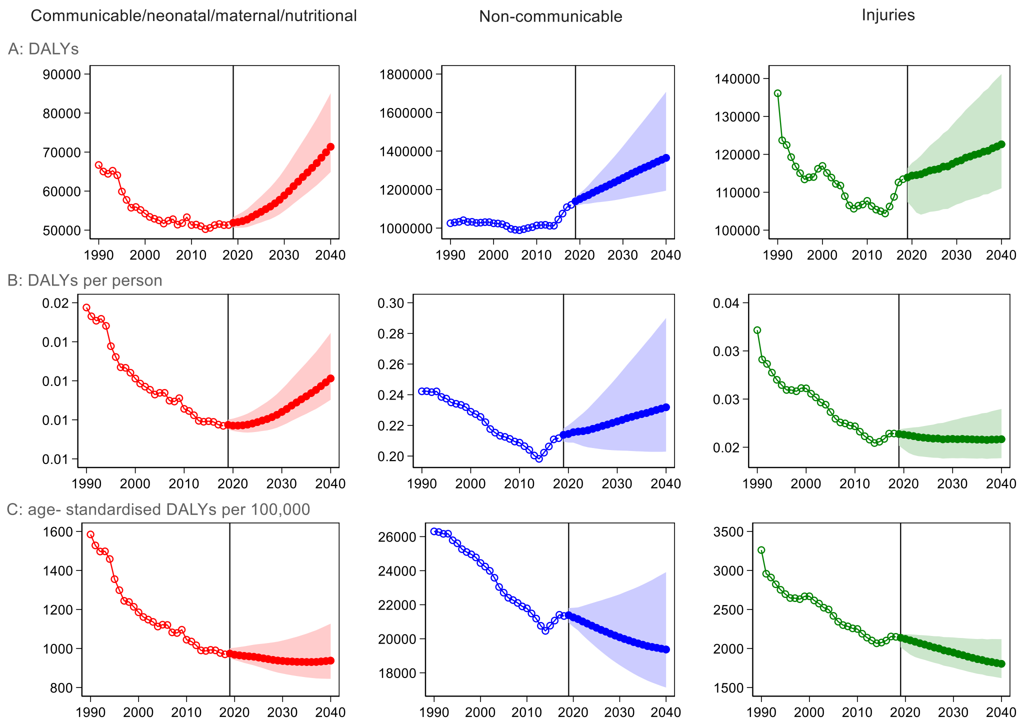
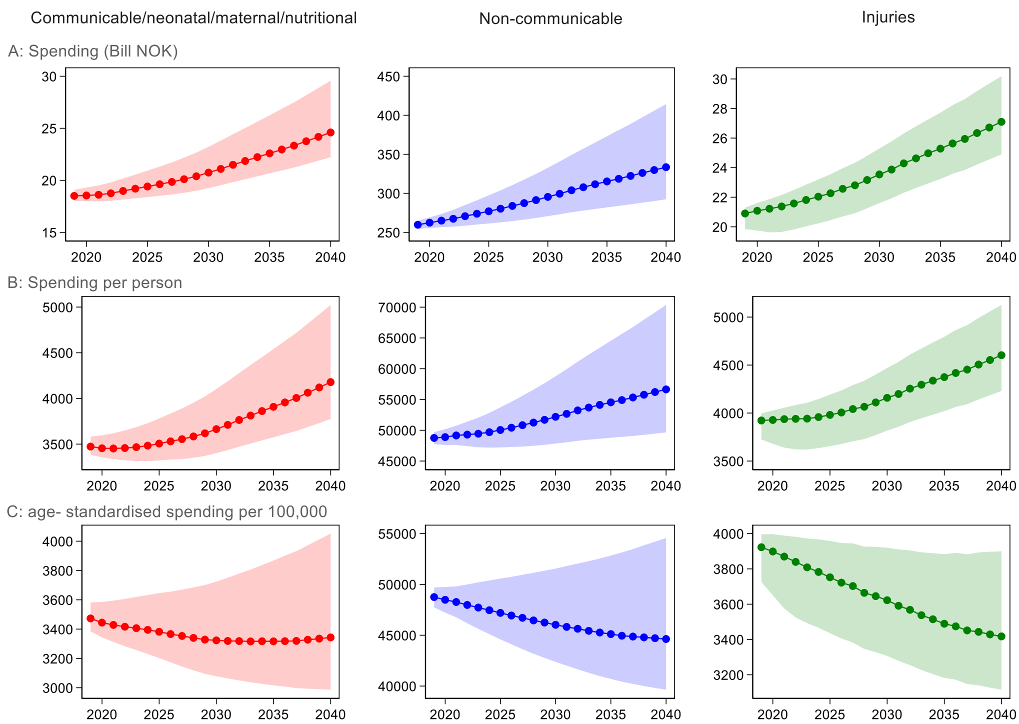


Figure 3: Current and future health spending, 2020-2040.



Note: the spending estimates are in 2019 Norwegian kroner

Figure 4: DALYs and spending for eight disease groups, 2020-2040.

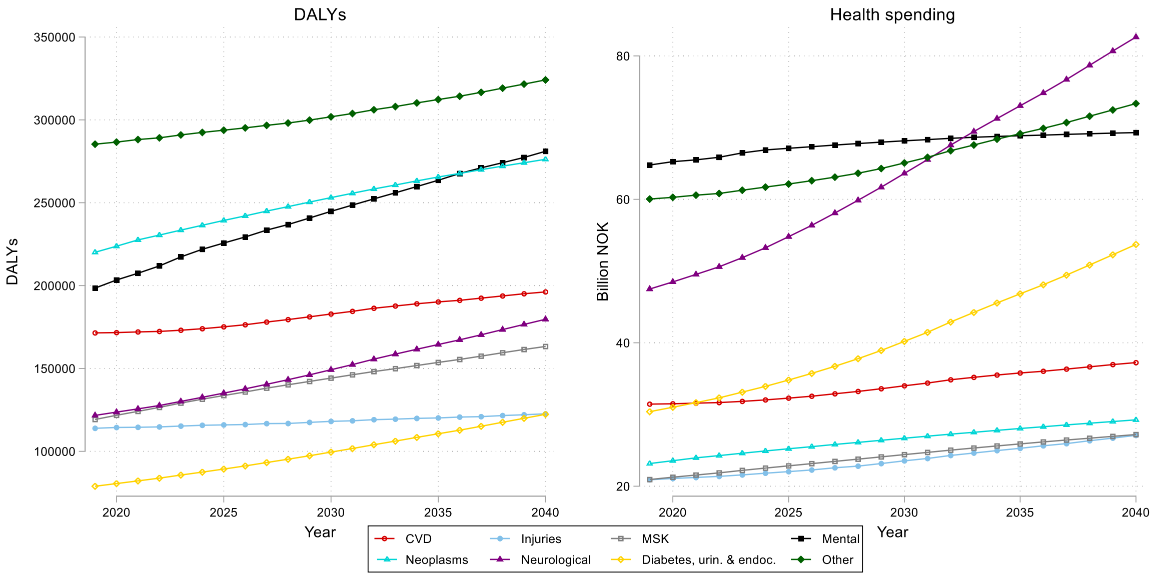


Figure note:
"Other" consist of other NCDs like digestive and respiratory diseases. But also, communicable diseases. For health spending, this category also contains expenditures on care, which is spending not directly related to diseases. The spending estimates are in 2019 Norwegian kroner.

4 Discussion

We project disease-specific spending based on a model combining demographic factors of population aging and population growth and epidemiological estimates of disease specific health loss and mortality. The results suggest future increases in the burden of disease and health spending. We explore how these projections vary by making scenarios where we change the underlying input in our model. From this, we find that increased spending is present in all scenarios except one. Future spending does not increase when we keep future age composition constant. When the projected increase in the proportion of elderly is accounted for by age-standardizing, future health spending decrease, which is due to a relatively healthier population.

Total health spending from diseases associated with high disability, like diabetes and neurological disorders (including dementia), is expected to increase substantially. However, total spending for diseases associated with high mortality, such as CVDs and neoplasms, is also expected to increase, but less so than for diseases like diabetes and dementia. This development is mainly due to the projected demographic trend of falling mortality rates for CVD and neoplasms. The mortality rates of the leading cause of death, CVDs have fallen dramatically in the period 1990-2019 and are expected to further decrease from 2020.

Suggested from the main risk factors accounting for the differences between the reference and better health scenario is that efforts to reduce the burden from smoking, high BMI, alcohol use, high blood pressure, and high blood sugar levels should be sustained, see Appendix Table 1.

Many factors will influence the future health spending: technologies, policies, age composition, economic growth, the epidemiological development, prices, and cost of care. Although efforts have been made to incorporate many of these factors in forecasts of heath spending, few models have strived to incorporate the epidemiological development by disease-specific prevalence explicitly. One reason may be that this requires forecasts of epidemiological development, which adds an additional layer of uncertainty.

4.1 Limitations

There are some important caveats to have in mind when interpreting the results. First, our projection approach is deterministic, albeit around scenarios representing better and worse health outcomes. Hence, the accuracy of spending estimates hinges on the accuracy of point estimates of future ill health. Second, the chosen approach follows the recent trends of reductions in years of life lost but would hinge upon the relationship of the number of life years lost to total DALYs remaining as they were in 2019 and that the spending profiles for different diseases and age groups be as they were in the past. Therefore, changes in cost, risk factors (e.g., diet), and prevention of future treatment are not fully considered in these calculations, even if past trends to the mortality component from these factors were sustained. Third, the model assumes that new technologies and changes in treatment practices will have a similar impact on the growth in the spending on services per DALY across health conditions. Fourth, the model assumes that the change in the volume of services provided per DALY will remain constant, and with that, the proportion treated for disease will remain the same.

Another limitation of our study, which we share with most other demand-driven health expenditure projection studies (Dybczak and Przywara, 2010), is that we ignore supply-side changes. Health technology development is an important supply-side factor that is highly likely to impact future health spending. It is inherently difficult to make reliable forecasts of the future development of health technology and its impact on expenditures (Dybczak and Przywara, 2010). Health technology improvements can greatly decrease future health spending if it prevents or delays age-associated diseases. Technological developments can also increase spending if it makes it possible to live longer with costly chronic diseases. Therefore, we refrain from incorporating health technology development and simply note that our projections include e.g., future cost of health care if technology development prevents or delays age-associated diseases.

One last thing to consider is that we are not accounting for economic growth. If the economy grows faster than health care costs, the share of gross domestic product (GDP) spent on health care will decrease. This will alleviate the burden of funding future health care. Historically, spending on health has outpaced economic growth in most OECD countries (OECD, 2021), posing a strain on public finances.

5 Conclusion

If we are to continue the level of spending per prevalent case of diseases in the future as we do today, health spending will increase dramatically. This increased future health spending is primarily due to an increased proportion of elderly with a high number of chronic conditions. Even the most optimistic, healthy ageing scenario will not offset this.

Acknowledgments

We thank participants at the workshop associated with Iversenseminaret for valuable input. The authors would also like to thank Tor Iversen for his longstanding contribution to the development of health economics in Norway and the Nordic countries.

References

Astolfi, R., Lorenzoni, L. & Oderkirk, J. 2012. Informing policy makers about future health spending: a comparative analysis of forecasting methods in OECD countries. *Health Policy,* 107**,** 1-10.

Dieleman, J. L., Baral, R., Birger, M., Bui, A. L., Bulchis, A., Chapin, A., Hamavid, H., Horst, C., Johnson, E. K. & Joseph, J. 2016. US spending on personal health care and public health, 1996-2013. *JAMA,* 316**,** 2627-2646.

Dieleman, J. L., Cao, J., Chapin, A., Chen, C., Li, Z., Liu, A., Horst, C., Kaldjian, A., Matyasz, T. & Scott, K. W. 2020. US health care spending by payer and health condition, 1996-2016. *JAMA,* 323**,** 863-884.

Dybczak, K. & Przywara, B. 2010. The role of technology in health care expenditure in the EU. Directorate General Economic and Financial Affairs, European Commission.

Foreman, K. J., Marquez, N., Dolgert, A., Fukutaki, K., Fullman, N., Mcgaughey, M., Pletcher, M. A., Smith, A. E., Tang, K., Yuan, C. W., Brown, J. C., Friedman, J., He, J., Heuton, K. R., Holmberg, M., Patel, D. J., Reidy, P., Carter, A., Cercy, K., Chapin, A., Douwes-Schultz, D., Frank, T., Goettsch, F., Liu, P. Y., Nandakumar, V., Reitsma, M. B., Reuter, V., Sadat, N., Sorensen, R. J. D., Srinivasan, V., Updike, R. L., York, H., Lopez, A. D., Lozano, R., Lim, S. S., Mokdad, A. H., Vollset, S. E. & Murray, C. J. L. 2018. Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016-40 for 195 countries and territories. *The Lancet,* 392**,** 2052-2090.

Fuchs, V. R. 1984. "Though much is taken": reflections on aging, health, and medical care. *Milbank Mem Fund Q Health Soc,* 62**,** 143-66.

GBD2019 Collaborators 2020. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet,* 396**,** 1204-1222.

Getzen, T. E. & Poullier, J.-P. 1992. International health spending forecasts: concepts and evaluation. *Social Science & Medicine,* 34**,** 1057-1068.

Goss, J. R. 2008. *Projection of Australian health care expenditure by disease, 2003 to 2033*, Australian institute of health and welfare Canberra.

Kinge, J. M., Dieleman, J. L., Karlstad, Ø., Knudsen, A. K., Klitkou, S. T., Hay, S. I., Vos, T., Murray, C. J. & Vollset, S. E. 2023. Disease-specific health spending by age, sex, and type of care in Norway: a national health registry study. *BMC medicine,* 21**,** 201.

Kinge, J. M., Sælensminde, K., Dieleman, J., Vollset, S. E. & Norheim, O. F. 2017. Economic losses and burden of disease by medical conditions in Norway. *Health Policy,* 121**,** 691-698.

Lee, R. & Miller, T. 2002. An approach to forecasting health expenditures, with application to the U.S. Medicare system. *Health Serv Res,* 37**,** 1365-86.

Lorenzoni, L., Marino, A., Morgan, D. & James, C. 2019. Health Spending Projections to 2030: New results based on a revised OECD methodology.

Manton, K. G. 2005. The demography of aging. *Principles and practice of geriatric medicine***,** 87-100.

Micah, A. E., Cogswell, I. E., Cunningham, B., Ezoe, S., Harle, A. C., Maddison, E. R., Mccracken, D., Nomura, S., Simpson, K. E. & Stutzman, H. N. 2021. Tracking development assistance for health and for COVID-19: a review of development assistance, government, out-of-pocket, and other private spending on health for 204 countries and territories, 1990–2050. *The Lancet,* 398**,** 1317-1343.

Murray, C. J., Vos, T., Lozano, R., Naghavi, M., Flaxman, A. D., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A. & Abdalla, S. 2013. Disability-adjusted life years

(DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. *The lancet,* 380**,** 2197-2223.

OECD 2021. *Health at a Glance 2021.*

Salomon, J. A., Haagsma, J. A., Davis, A., De Noordhout, C. M., Polinder, S., Havelaar, A. H., Cassini, A., Devleesschauwer, B., Kretzschmar, M. & Speybroeck, N. 2015. Disability weights for the Global Burden of Disease 2013 study. *The Lancet Global Health,* 3**,** e712-e723.

Salomon, J. A., Vos, T., Hogan, D. R., Gagnon, M., Naghavi, M., Mokdad, A., Begum, N., Shah, R., Karyana, M., Kosen, S., Farje, M. R., Moncada, G., Dutta, A., Sazawal, S., Dyer, A., Seiler, J., Aboyans, V., Baker, L., Baxter, A., Benjamin, E. J., Bhalla, K., Bin Abdulhak, A., Blyth, F., Bourne, R., Braithwaite, T., Brooks, P., Brugha, T. S., Bryan-Hancock, C., Buchbinder, R., Burney, P., Calabria, B., Chen, H., Chugh, S. S., Cooley, R., Criqui, M. H., Cross, M., Dabhadkar, K. C., Dahodwala, N., Davis, A., Degenhardt, L., Diaz-Torne, C., Dorsey, E. R., Driscoll, T., Edmond, K., Elbaz, A., Ezzati, M., Feigin, V., Ferri, C. P., Flaxman, A. D., Flood, L., Fransen, M., Fuse, K., Gabbe, B. J., Gillum, R. F., Haagsma, J., Harrison, J. E., Havmoeller, R., Hay, R. J., Hel-Baqui, A., Hoek, H. W., Hoffman, H., Hogeland, E., Hoy, D., Jarvis, D., Karthikeyan, G., Knowlton, L. M., Lathlean, T., Leasher, J. L., Lim, S. S., Lipshultz, S. E., Lopez, A. D., Lozano, R., Lyons, R., Malekzadeh, R., Marcenes, W., March, L., Margolis, D. J., Mcgill, N., Mcgrath, J., Mensah, G. A., Meyer, A. C., Michaud, C., Moran, A., Mori, R., Murdoch, M. E., Naldi, L., Newton, C. R., Norman, R., Omer, S. B., Osborne, R., Pearce, N., Perez-Ruiz, F., Perico, N., Pesudovs, K., Phillips, D., Pourmalek, F., Prince, M., Rehm, J. T., Remuzzi, G., Richardson, K., et al. 2012. Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010. *Lancet,* 380**,** 2129-43.

Singer, B. H. & Manton, K. G. 1998. The effects of health changes on projections of health service needs for the elderly population of the United States. *Proc Natl Acad Sci U S A,* 95**,** 15618-22.

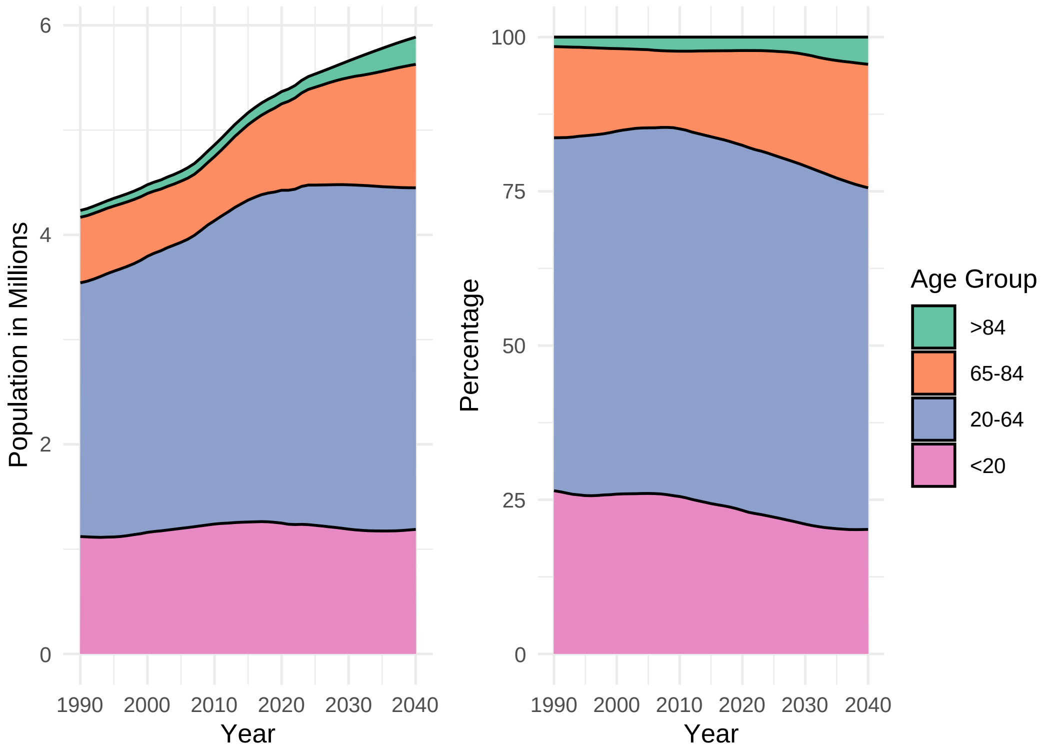
Statistics Norway 2021. National accounts - Health accounts. Statistics Norway,.

Thomas, M. & Tømmerås, A. 2022. Norway's 2022 national population projections. Reports.

Vos, T., Goss, J., Begg, S. & Mann, N. 2007. Projection of health care expenditure by disease: a case study from Australia. *Background paper for United Nations 2007*.

Appendix

Appendix Figure 1: Norwegian population by age from 1990 to 2040.



Appendix Table 1: Norway's ten leading risk factors and the difference in years of life lost (YLLs) between the reference forecast and better health scenario in 2040, with rankings relative to Western Europe. Values are in thousands. The lower and upper estimate are from the 95% uncertainty interval. Adapted from Foreman et al. (2018).

Rank	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**#7**	**#8**	**#9**	**#10**
Norway	Tobacco	High body-mass index	High blood pressure	High fasting plasma glucose	Alcohol use	High total cholesterol	Ambient particle matter	Low fruit	Low veget-ables	Low nuts and seeds
Western Europe	Tobacco	High body-mass index	Alcohol use	High blood pressure	High fasting plasma glucose	High total cholesterol	Ambient particle matter	Low fruit	Low whole grains	Occupa-tional asbestos
Estimate Norway	96.6	42.3	35.8	31.8	30.5	23.2	15.9	11.1	11	10.5
Lower Norway	72.3	27.9	19.2	13.9	19.5	11.3	9.8	5.7	5.5	4.6
Upper Norway	132.3	62	62.6	59.5	45.4	41.9	24.1	19.7	19.1	18.2