Objective
To estimate the long-term fiscal consequences of attention deficit hyperactivity disorder (ADHD) on the German government and social insurance system based on differences in educational attainment and the resulting differences in lifetime earnings compared with non-ADHD cohorts.

Methods
Differences in educational attainment between ADHD and non-ADHD cohorts were linked to education-specific earnings data. Direct and indirect tax rates and social insurance contributions were linked to differences in lifetime, education-specific earnings to derive lost tax revenue in Germany associated with ADHD. The framework enabled us to investigate potential benefits from investments in hypothetical interventions that could improve the educational attainment of ADHD individuals.

Results
The lifetime net tax revenue for a non-ADHD individual was approximately €80,000 higher compared to an untreated ADHD individual. The fiscal burden of untreated ADHD, based on a cohort of n=31,844 born in 2010, was estimated at €2.5 billion in net tax revenue losses compared with an equally-sized non-ADHD cohort. ADHD interventions providing a small improvement in educational attainment resulted in fiscal benefits from increases in lifetime tax gains. The projected rate of return suggests that for each Euro spent on a new ADHD intervention the government and social insurance system may
gain €1.39 in lifetime discounted net tax revenue and €3.02 in discounted gross tax revenue.

**Conclusions**
ADHD results in long-term financial loss due to lower education attainment and lifetime reduced earnings and resulting lifetime taxes and social contributions paid. Investments in ADHD interventions allowing more children to achieve their educational potential may offer fiscal benefits generating a positive rate of return.

**Background**
Attention deficit hyperactivity disorder (ADHD) is a chronic neurobiological disorder described as a condition in children and adults and characterised by a symptom cluster of inattention, hyperactivity and impulsivity according to DSM-IV and ICD-10 criteria\(^1-3\). The disorder is relatively common with estimated prevalence rates, in the US and Germany, of 4-12% in children\(^4\) depending on the diagnosis criteria applied, and consistently above 4% in adults\(^5, 6\). The time to ADHD diagnosis can often be delayed with estimates suggesting up to 18 months until diagnosis in some cases, and for ADHD adults, in the majority of cases no childhood diagnosis was reported\(^6\).

Numerous studies have described the impact that ADHD can have on educational outcomes. For example, children with ADHD are regularly found to have lower educational attainment, increased likelihood of dropping out of school and grade retention compared to children without ADHD\(^7-10\). Although reduced educational performance in ADHD children has some immediate societal cost implications, the costs of reduced educational achievement may reduce lifetime opportunities for ADHD individuals because of education-linked wage effects that will persist over the course of life\(^11\), 12\).

Education is deemed as a human capital asset that affects individuals and society suggesting that the economic impact of ADHD on educational attainment can be manifold when considered over the lifetime of the individual\(^12\). In human capital economics, the relationship between higher educational attainment and earnings is well-established\(^13-14\). Hence, considering the economic losses associated with ADHD, in particular those linked explicitly to education, it should be possible to investigate the positive effects which interventions that improve educational achievement can have on governments’ fiscal accounts. Economic investigations of ADHD that focus solely on health service costs likely underestimate the true costs as they fail to consider the psychosocial consequences of the disorder in adults, which include reduced work activity, increased substance abuse and traffic.
accidents, more frequent incarceration, higher rates of unemployment, and increased mortality, all of which represent costs for the society\textsuperscript{15, 16}.

The health service and societal impact has been investigated in burden of illness studies\textsuperscript{17}. However, it is increasingly recognised that medical conditions that cause people to withdraw from the work force, work inefficiently (i.e. presenteeism), retire or die prematurely can also impact governments\textsuperscript{18}. In this context, it is possible to quantify increased government and/or social insurance costs to individuals with ADHD due to higher health care spending, unemployment costs, disability, and the consequences of abnormal social norms such as drug addiction and incarceration. In addition, reduced earnings and employment opportunities in ADHD adults represent lost tax revenue for governments and the social insurance system that can be assessed using accepted human capital and fiscal accounting methods\textsuperscript{19}.

In this study we aimed to estimate the fiscal consequences of untreated ADHD and the theoretical benefits attributed to interventions that may change educational attainment in ADHD populations.

**Methods and data**

We based our estimations on the established relationship between education and lifetime earnings\textsuperscript{13, 14, 20, 21}. To estimate the fiscal consequences of untreated ADHD from the government perspective, we linked education-specific earnings in Germany to previously published data demonstrating differences in educational attainment for ADHD individuals compared with non-ADHD individuals\textsuperscript{9}. By applying direct and indirect taxation rates, and unemployment rate differences between ADHD and non-ADHD cohorts, we assessed the fiscal consequences attributed to ADHD. Additionally, the framework enabled us to explore how changing educational attainment based on ADHD interventions, introduced early in life, will influence government fiscal accounts.

The analysis described here follows the methodology described by Connolly et al.,\textsuperscript{22} to project revenue implications for government from investments in assisted reproduction programmes. The analysis for ADHD and non-ADHD individuals was based on the educational attainment data reported for a German, matched-controlled population\textsuperscript{9}. The study used aimed at systematically assessing the profile of lifetime psychiatric comorbidity and psychosocial functioning in a German sample of adults with ADHD compared to a population-based, gender- and age-matched control group and at examining whether patients with ADHD and lifetime comorbid psychiatric diagnoses differed from patients with pure ADHD in their psychosocial functioning. The study reported educational attainment and unemployment
data reporting that 8.6% of untreated ADHD individuals held a university degree and 61.4% graduated from occupational training. In contrast, the corresponding figures for non-ADHD controls were 25.7% and 60%, for university and occupational training, respectively. In addition, the reported unemployment rate was by 25% higher for untreated ADHD individuals compared with the control group.

A simulation model was constructed quantifying the lifetime government transfer payments attributed to average German individuals with ADHD and without ADHD. Government transfer payments represent annual money flows from governments to their citizens for services such as health care and education and disability allowances and benefits. The model generated the gross tax revenue which is the present value (PV) of the accumulated direct and indirect tax and social insurance paid by average German ADHD and non-ADHD individuals (equation 1). In addition, the model projected the net tax revenue for the government by deducting government transfer payments from the gross tax revenue. The net tax revenue was presented as the fiscal Net Present Value (NPV) of ADHD and non-ADHD individuals at any point in time (equation 2). Furthermore, the model evaluated a hypothetical long-term health intervention, described in the following sections of this study, which was considered to influence educational achievement and estimated the return on investment for the government in terms of the gross and net tax revenue that would result from future education-linked earnings.

\[
GrossTaxRevenue_j = \sum_{i=1}^{L_p} \frac{DirectTax_{ji} + IndirectTax_{ji} + SocialInsurance_{ji}}{(1+r)^t} (1)
\]

\[
NetTaxRevenue_j = \sum_{i=1}^{L_p} \frac{(DirectTax_{ji} + IndirectTax_{ji} + SocialInsurance_{ji}) - (Education_{ji} + Healthcare_{ji} + OtherTransfers_{ji})}{(1+r)^t} (2)
\]

Where \( j \): ADHD status; \( i \): Year; \( r \): Discount rate; \( L_p \): Life expectancy (until the age of retirement)

In order to project the future lifetime earnings of an average individual in Germany, we employed the simplest form of the Mincer model according to which lifetime earnings are a function of schooling years and work experience and considered that other explanatory variables of earnings such as gender, ethnicity, socio-economic background and geography were identical for both untreated ADHD and non-ADHD individuals\textsuperscript{14,21}. A study estimating the coefficients of a Mincer function for Germany was identified from the literature\textsuperscript{23}. The study used the 1985-2001 German Socio-Economic Panel study (GSOEP), a dataset consisting of individual and household micro-data
which was considered a good reflection of the overall German population\textsuperscript{24}. In order to reflect current prices and consistent with the generational accounting methodology\textsuperscript{24}, earnings were inflated over time to reflect annual increases in productivity. We assumed a productivity inflation rate equal to the current inflation rate of 2.80%\textsuperscript{25} which we also applied to all government transfer costs included in the model in order to avoid an overestimation of lifetime earnings. The projected earnings were adjusted for unemployment using current age-specific unemployment rates in Germany in non-ADHD cohorts and accounting for 25\% higher unemployment in untreated ADHD individuals as previously described\textsuperscript{9}.

The transfer payments considered in our analysis were education, health care costs and all other non-defined transfer payments. Education cost data, by level of education, were obtained from the published literature and adjusted to reflect current prices\textsuperscript{26}. Non-defined transfer payments from the German Household survey were included to reflect transfers from the government to individuals. Transfer payments also showed an age-specific pattern\textsuperscript{27}. Therefore, an exponential mathematical form was applied to the available data in order to interpolate non-defined transfers over the timeframe of the model\textsuperscript{28}.

Annual costs of treating ADHD in Germany were included in the model based on the study reported by Schlander et al\textsuperscript{29}. The annual average health costs including costs of medicines and doctor consultations for people with ADHD ranged from €520 – €1,147, and the relationship was age-dependent with higher costs in older subjects. The age-specific ADHD costs reported by Schlander were interpolated in order to derive a cost for ADHD over the lifetime of people with ADHD. In addition to the costs described by Schlander, in the model we included an additional cost of €350 associated with introducing a new therapeutic or pharmacological intervention for the treatment of ADHD. In the model it was assumed that ADHD individuals have higher health costs even if they are not treated for ADHD, due to more resource-intense health seeking behaviours. All costs were converted to 2010 prices and inflated at the current annual cost inflation rate\textsuperscript{25}.

Government tax revenue was modelled as a function of age-specific earnings. The types of tax modelled were the direct and indirect taxes (e. G. VAT for consumption) and social insurance contributions. Other tax that may apply to Germany such as road tax and property tax were omitted from this study suggesting our estimate of annual per capita tax receipts were an underestimate. At each year in the model, direct and indirect taxes represented a fixed percentage of an individual's earnings.
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**Table 1:** Cumulative discounted gross revenue and net tax revenue at different time points for untreated ADHD and non-ADHD individuals with simulated changes in education gains with treatment.
To estimate the fiscal consequences of untreated ADHD nationally, a cohort analysis was simulated applying an ADHD prevalence of 4.7%. The model applied the same annual survival probabilities of the general German population for both untreated ADHD and non-ADHD individuals. In order to estimate the productive life expectancy of an individual, the model assumed that individuals with secondary education, occupational training and university degrees enter the work force at different ages. The time horizon of the analysis was set at the age of retirement and average retirement age was set at 65 years for both ADHD and non-ADHD individuals. A progressive tax rate of 18.7% – 27% was used for direct taxes, and national insurance contributions were set at 20.5%. Based on authors’ calculations from the 2008 German household survey data, the disposable income was set at 47.5% of total income and the indirect tax at 20%. Finally, the European Central Bank discount rate of 1.75% was used to discount future government costs for transfer payments and tax revenue.

**Results**

The annualised undiscounted government spending and gross tax revenue for an average individual with untreated ADHD and without ADHD is illustrated in Figure 1. Based on the educational attainment probabilities for Germany the model predicted that an untreated ADHD individual generates lower gross tax revenue and marginally higher lifetime government transfer payments (health care, education and non-definable transfer payments), compared to a non-ADHD individual. In particular, the model output illustrates that during the first two decades of life, untreated ADHD and non-ADHD individuals incur mainly costs for governments attributed to education, health care and non-defined transfers. An untreated ADHD individual incurs lower educational costs since there is less likelihood of attending tertiary education compared to a non-ADHD individual. However, an untreated ADHD individual is expected to incur higher health care costs. Between the ages of 17 and 24 we can observe increased government gross tax revenue as a result of individuals entering the work force and starting to pay taxes. Costs rise during the later stages of life since wages start to diminish whilst health care and all other transfers costs rise (depicted as negative in Figure 1).

Table 1 illustrates the gross and net tax revenue generated by the model for ADHD and non-ADHD groups along with the underlying educational attainment proportions. In addition, the table presents the corresponding results and underlying educational attainment proportions for the hypothetical ADHD-targeting intervention. The gross tax revenue at the age of retirement for an ADHD and non-ADHD individual was €567,977 and €632,638, respectively, implying that ADHD imposes a fiscal burden for the government as it results in less tax revenue. The difference in gross tax
revenue indicates the size of the lifetime fiscal burden which was estimated to be €64,660 per ADHD individual. The net tax revenue results indicate that both ADHD and non-ADHD individuals carry a negative fiscal balance as they consume publically-funded health care, allowances and education services. However, as they enter the work force the government transfer payments are paid back through direct and indirect taxes. The age at which the accumulated gross tax revenue outweighs the accumulated government spending for transfer payments, in other words, the age at which an individual's net tax revenue turns positive, was 35 and 33 for ADHD and non-ADHD individuals, respectively. By the age of retirement, an ADHD individual generates net tax revenue of €244,938. The corresponding net tax revenue of a non-ADHD individual was €322,786. Thus, the estimated net fiscal burden of ADHD was estimated at approximately €80,000 per person.

**Figure 1** Annualised tax revenue and government costs by ADHD status over the life course for untreated ADHD and non-ADHD individual

Based on 677,947 births in 2010 we estimated 31,844 ADHD children that do not receive any treatment, assuming a 4.7% ADHD frequency of the condition in the cohort, and compared them with an equal cohort of non-ADHD controls to derive the national gross and net fiscal burden of ADHD. The results of the national analysis showed that by the age of retirement, the gross tax revenue was €18.1 and €20.2 billion for ADHD and non-ADHD cohorts, respectively, implying a gross lifetime fiscal burden of more than €2 billion. The net tax revenue for the government was €7.8 billion for ADHD and €10.3 billion for non-ADHD cohorts suggesting a net tax revenue burden of €2.5 billion for the government and the social insurance system.
In order to evaluate the potential returns for government from investing in interventions that target ADHD symptoms in early life, and may change the expected educational attainment, a hypothetical ADHD health intervention was treated as a public investment and the benefits to government were projected in terms of future gross and net tax revenue based on differences in educational attainment. In the analysis we arbitrarily used a hypothetical total daily cost of €0.95, for an ADHD intervention initiated at the age of 7 and 11-year duration. The hypothetical treatments were assumed to be effective and thus, influence the average educational attainment. To present the fiscal impact of a new intervention, we hypothesized two different scenarios for the intervention’s potential to treat ADHD and thus, improve educational attainment, namely, an optimistic scenario and a conservative scenario. Table 1 illustrates the educational attainment mix for the two hypothetical scenarios and the corresponding gross and net tax revenue at convenient points in time. The hypothetical analysis presented here implies that interventions may have different effectiveness and hence result in different longer-term educational attainment outcomes. To isolate the effects of education we assumed that the new intervention has no effect on the unemployment level. The results suggested that a small increase in educational attainment may generate significant fiscal benefits for the government. In the conservative scenario, for each euro spent from the German social insurance on the new intervention the government is estimated to gain €3.02 in gross tax revenue and €1.39 in net tax revenue.

Discussion
In 2009 the World Health Organisation (WHO) released the WHO Guide to Identify the Economic Consequences of Disease and Injury. Within the WHO guide the impact of population health on government was described where the report acknowledged that injury and illness can impact government fiscal accounts both in terms of lost tax revenue and increased transfers costs. The implications of this report suggest that preventing illness would likely have a positive impact for government as more people would be working and paying taxes. In the spirit of the WHO guide, we sought to understand how ADHD might influence fiscal accounts using a “government perspective” accounting framework.

The main outcome metric considered in the economic model described here was the differences between educational attainment in untreated ADHD and non-ADHD individuals that has been reported in numerous studies. In economic theory, higher educational attainment implies a higher potential for increased lifetime earnings which in turn, provides the basis for higher tax revenue. When considering the long-term economic prospects of a society, the populations’ level of education is deemed as an important determinant of economic growth. An analysis of cross-country data
estimated that an additional year of schooling roughly raises the growth rate by 0.44% per year\(^7\).

The relationship between educational attainment and ADHD status, based on a German specialist centre, has been documented by Sobanski et al. and served as the basis for modelling in our study\(^9\). When differences in education achievement are linked with human capital theory regarding education levels, earnings and long-term macroeconomic growth, the broader consequences of ADHD can be projected based on these differences in education\(^3, 14, 20, 21, 26\). As described in this study, education levels achieved within the population can have direct fiscal consequences for government that can be assessed. From the perspective of government, reduced educational attainment may result in lower lifetime wages for ADHD children and that would, in turn, translate into less taxable income and consequently reduced tax revenue and social contributions. This finding is supported by previous studies in the educational literature that highlight lost tax revenue implications for governments associated with school dropout rates\(^38\). However, it is worth noting that there are inconsistencies regarding the impact that ADHD may have on educational attainment, with previous studies showing that ADHD has limited influence on long-term educational outcomes\(^7\).

The likelihood of reduced educational achievement associated with ADHD suggests the need to intervene early in life to try and avert some of the negative consequences of the disorder. This is particularly important with respect to schooling because education is accumulated early in life when ADHD symptoms are often first diagnosed and more pronounced. As ADHD children progress towards adulthood, even though ADHD symptoms may not be present as adults, the manifestation of the disorder on education attainment in early life can have a residual education effect that lasts throughout life. Aligned with this perspective is a policy briefing document on lifelong learning released by the OECD which noted the importance of early childhood for human capital formation i.e education that will help children develop the necessary skills to survive in a rapidly evolving world\(^11\).

Our analysis is based on the evidence generated by one exploratory observational study in Germany assessing the effect of ADHD on educational attainment thus, reflecting the local epidemiologic, social and economic characteristics. Given the long-term horizon of this analysis, a modelling approach quantifying the economic impact of ADHD was considered as the most appropriate approach for assessing the fiscal consequences of the disorder. Our analysis is based on the human capital economics assumption of the causal relationship between the level of education and lifetime earnings. Ideally, long-term observational data would be required.
to quantify the lifetime earnings' differences between untreated ADHD and non-ADHD individuals. Moreover, our analysis is based on several long-term projections of volatile economic figures which inevitably introduce uncertainty. Forecasting key model's inputs in the long-term, such as the cost and productivity inflation, age-specific unemployment rates, government transfer payments and health care costs is based on current data which may not accurately reflect the future situation. Predicting the future earnings and tax paying capacity of a cohort is dependent on several exogenous parameters which may not be included in the current econometric forecast models (e.g. technological change, educational policy changes, and tax system reforms).

Our model assumes that ADHD individuals incur higher health care costs based on reported costs from Germany\textsuperscript{29}. However, there is reason to believe these costs are an underestimate as behavioural therapy has become more commonly used in Germany which would increase treatment cost. Consequently any changes in annual treatment costs could influence the discounted net tax revenue described in this paper. To better understand the fiscal consequences of ADHD interventions would require observational evidence to reflect the long-term health care resource use patterns of ADHD adults. Additionally, our analysis does not assume differences in the survival between ADHD and non-ADHD individuals, hence future analyses should take into account the net fiscal effect of survival differences between these two cohorts.

In this research we quantified the fiscal impact of a new ADHD intervention on government accounts by modelling different scenarios regarding educational attainment. It should be noted that the educational attainment used for our scenario analysis were purely hypothetical. In order to accurately quantify the fiscal consequences of ADHD-targeting interventions, long-term observational data would be needed. Our analytic framework assumes that ADHD in children and the reduced educational attainment achieved early in life can impact government fiscal accounts when these children reach working ages. A recent UK policy analysis highlighted that investments in evidence-based prevention, early intervention and treatment for mental disorders can have economic benefits that go far beyond the health sector\textsuperscript{39}. The analysis suggested that, in light of austerity measures, policy appraisals should go further than the cost-effectiveness and assess the cross-sectoral impact not only of treatments but also of preventive actions\textsuperscript{39}.

In contrast with the traditional technology appraisal methods that measure outcomes in quality-adjusted life years (QALYs), our framework projects economic benefits associated with changes in population health status in relation to spending on discrete health programs. In this respect it is possible to view models that reflect the government perspective as budget impact
models that assess the effect of health changes across different government fiscal accounts, and accounts for any tax revenues that may arise through increased societal productivity. In this context, the analysis follows a discounted cash flow methodology widely used in financial analysis.

Conclusions
Using methods from human capital theory and the reported educational attainment evidence for ADHD and non-ADHD individuals, we showed that reduced educational attainment in ADHD represents a significant financial burden on government because of reduced taxable income and consequently reduced tax revenue. The average lost net tax revenue for each untreated ADHD individual represents a loss of approximately €80,000 over the productive lifetime. Our analysis suggests that investments in ADHD interventions that allow more individuals to achieve their educational potential compared with untreated ADHD offers cross-sectoral benefits which can be quantified by tax revenue. These benefits transcend several sectors of the economy and show that a health intervention may generate wider and quantifiable economic benefits.

References
Chapter 6


29. Schlander M, Schwarz O, Trott EG, Viapiano M, Bonauer N. Health Service Expenditures for Patients with a Diagnosis of Attention-Deficit/Hyperactivity Disorder (ADHD) in Germany – An Age and Gender Specific Analysis. Value in Health 2008; 11(6):A588