Burden of Disease analyses: Norway

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1. Tracking Educational Inequalities in Cause-Specific Years of Life Lost (YLLs)

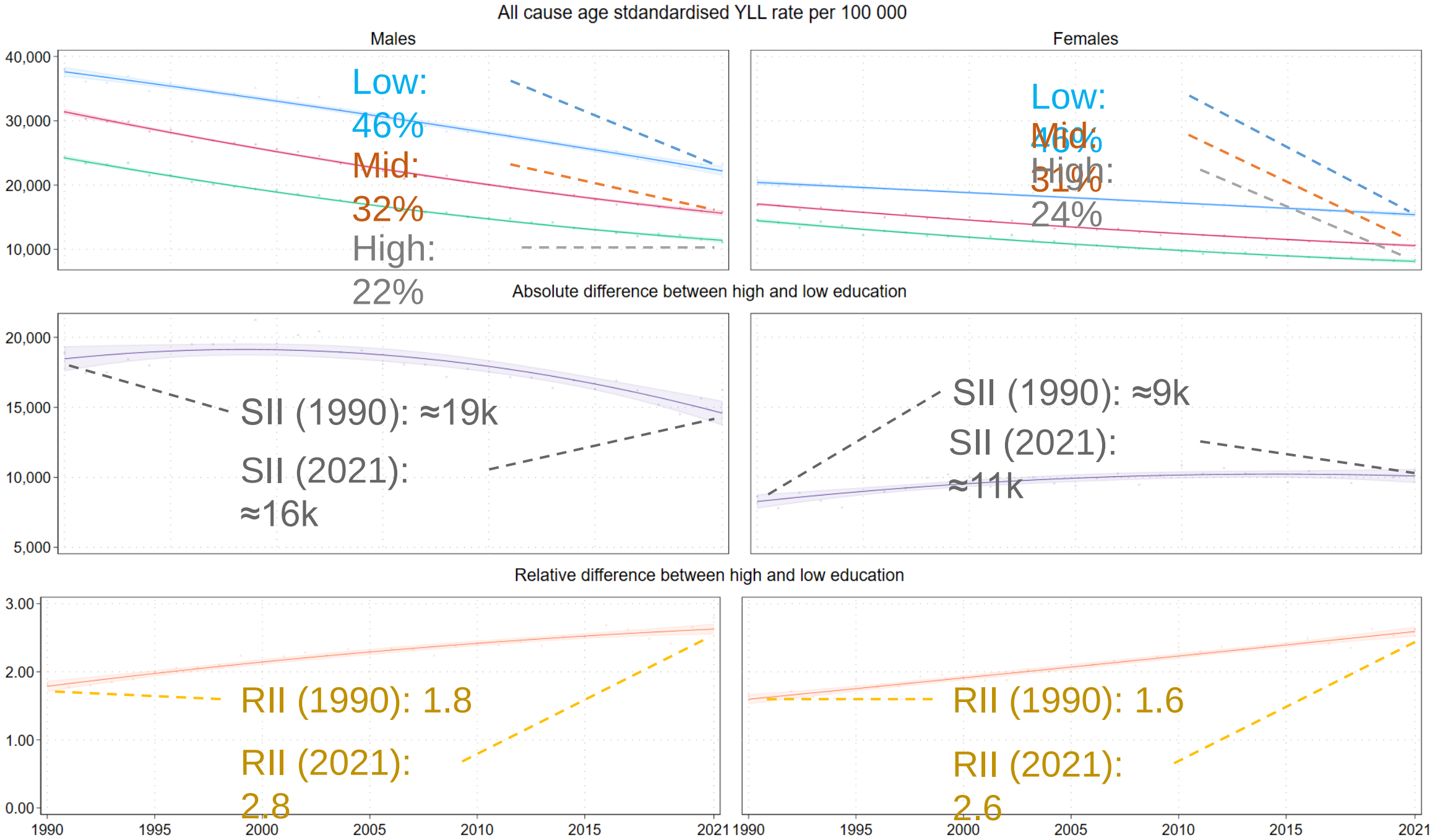
Methods

- Nationwide registry linkage (1990–2021)
- Causes of death classified by GBD level-3 (~130 causes)
- Educational achievement:
  - Low (< upper secondary), middle (upper secondary), high (tertiary)
  - Own education from age 28+ / Parental education < 28
- Outcome: Age-standardised years of life lost (YLL) rates
- Inequality measures:
  - Slope Index of Inequality (SII → absolute gaps)
  - Relative Index of Inequality (RII → relative gaps)
- Poisson regression with splines for average annual percentage change.

$$YLL = \sum_i D_i \times L_i$$

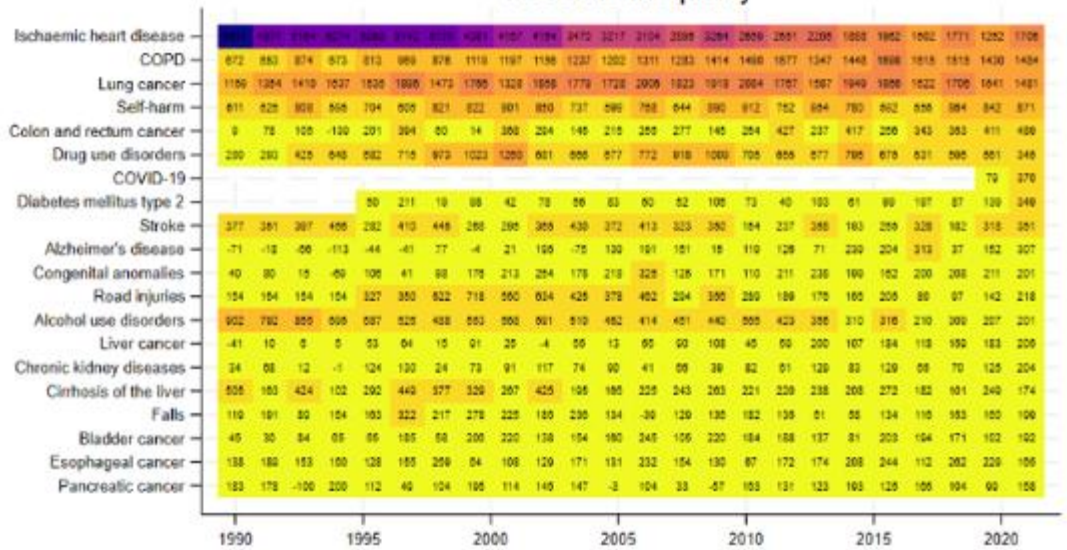
where D_i represents deaths at age i and L_i is the standard life expectancy at age i.

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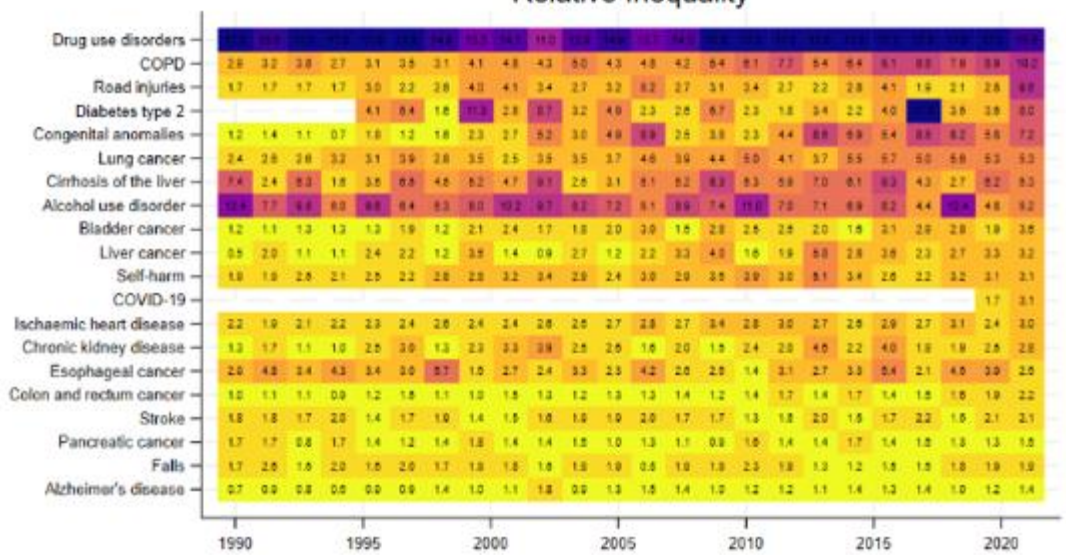

All cause age stdandardised YLL rate per 100 000
Males
Females
40,000
30,000
20,000
10,000
Low:
46%
Mid:
32%
High:
22%
Low:
46%
Mid:
31%
High:
24%
Absolute difference between high and low education
20,000
15,000
10,000
5,000
SII (1990): ≈19k
SII (2021):
≈16k
SII (1990): ≈9k
SII (2021):
≈11k
Relative difference between high and low education
3.00
2.00
1.00
0.00
RII (1990): 1.8
RII (2021):
2.8
RII (1990): 1.6
RII (2021):
2.6
1990
1995
2000
2005
2010
2015
2021

Males

Absolute Inequality

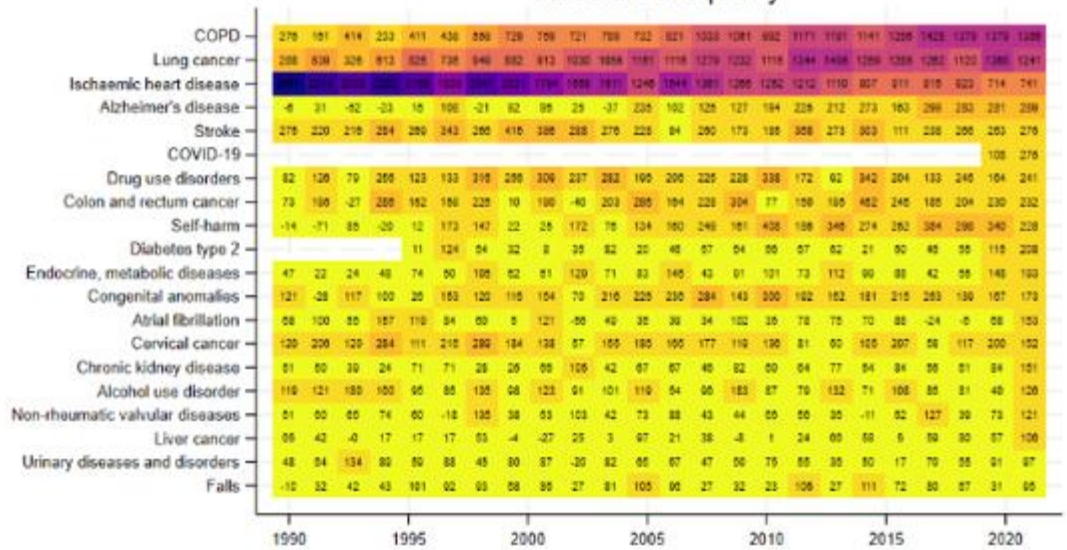


Relative Inequality

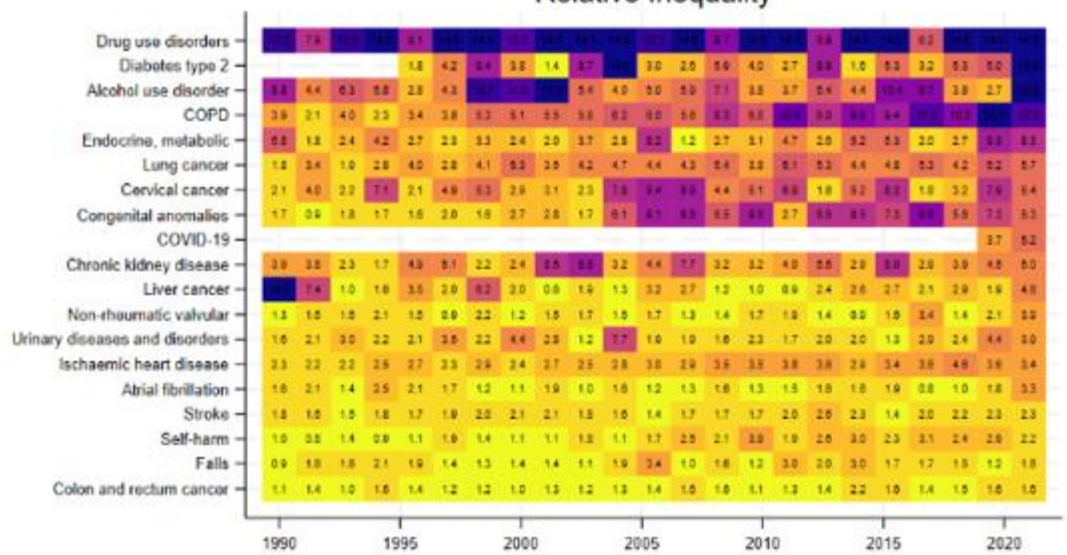


Females

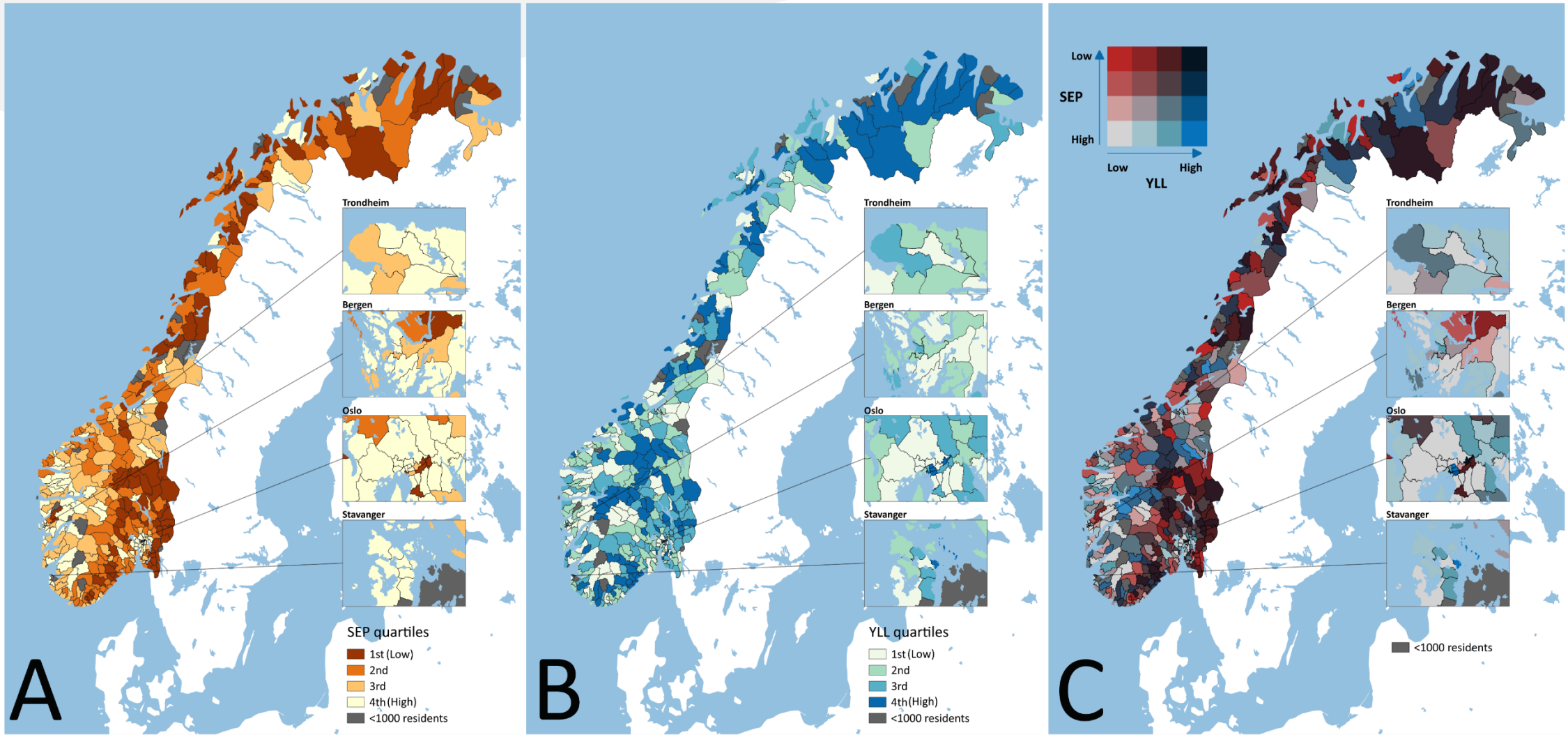
Absolute Inequality



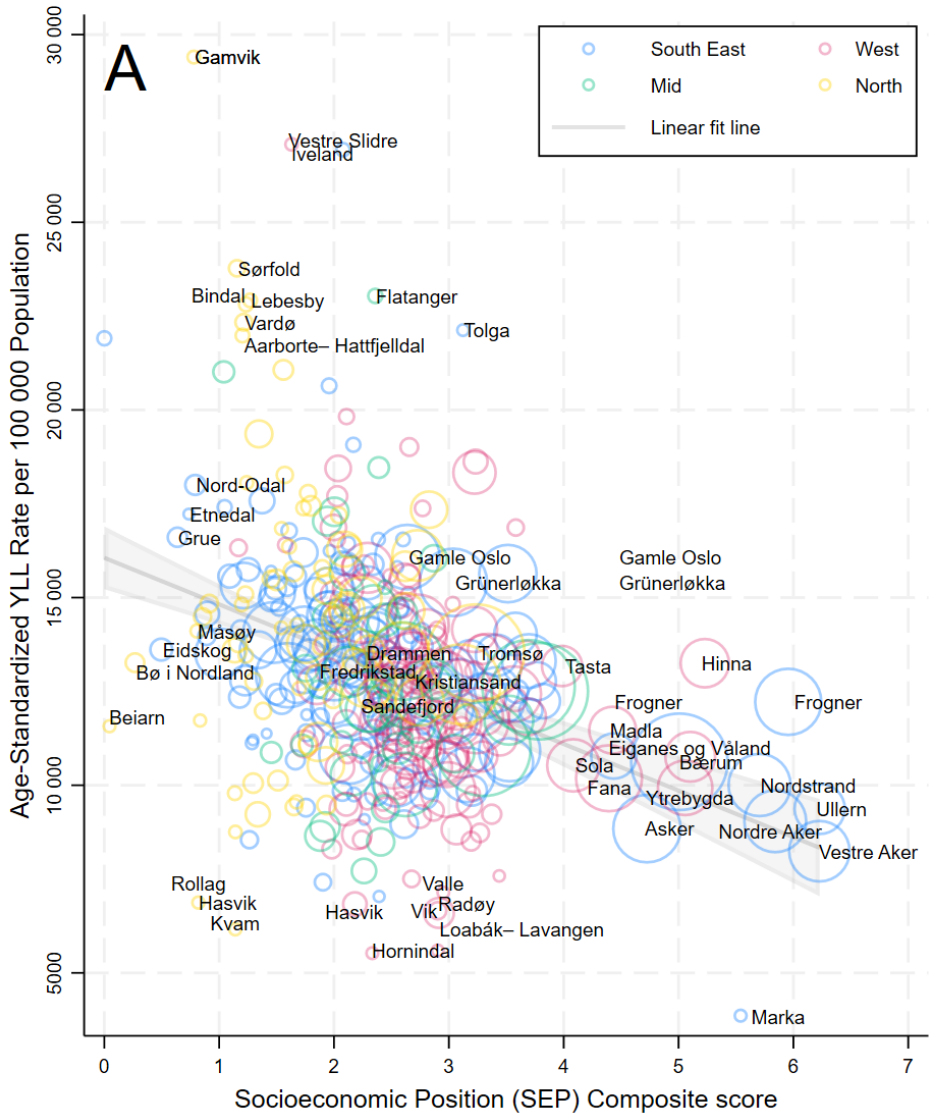
Relative Inequality



Geographical and socio-economic inequalities in years of life lost across Norwegian municipalities and city districts in 2019


A
Trondheim
Bergen
Oslo
Stavanger
SEP quartiles
1st (Low)
2nd
3rd
4th (High)
<1000 residents
B
Trondheim
Bergen
Oslo
Stavanger
YLL quartiles
1st (Low)
2nd
3rd
4th (High)
<1000 residents
C
Low
SEP
High
Low
High
YLL
Trondheim
Bergen
Oslo
Stavanger
<1000 residents

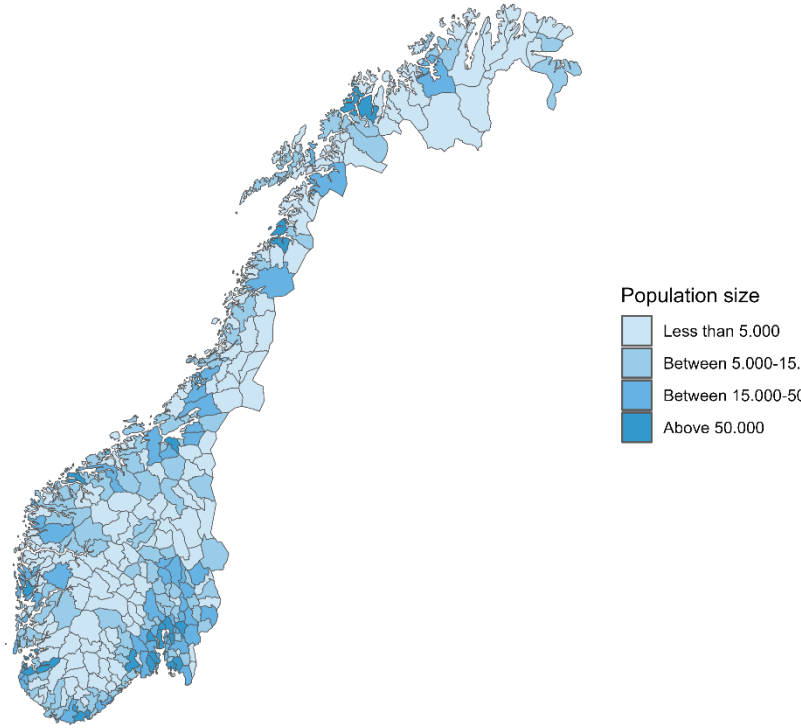
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Factor	Relative difference IRR (95% CI)		Absolute difference YLL rate per 100 000	
–	Model 1 (crude)	Model 2 (adj. age and sex)	Model 1 (crude)	Model 2 (adj. age and sex)
SEP	–	–	–	–
Q1 (high SEP, ref.)	1.00	1.00	0	0
Q2	1.21 (1.11–1.31)	1.07 (1.04–1.10)	2515 (1381–3648)	977 (622–1333)
Q3	1.32 (1.23–1.42)	1.12 (1.09–1.15)	3908 (2892–4924)	1717 (1353–2081)
Q4 (low SEP)	1.48 (1.41–1.55)	1.15 (1.07–1.24)	5859 (4798–6919)	2,127 (1000–3254)
Centrality	–	–	–	–
1 (urban, ref.)	1.00	1.00	0	0
Gr. 2 (intermediate)	1.28 (1.13–1.45)	1.08 (1.05–1.12)	3102 (1458–4746)	1154 (754–1555)
Gr. 3 (rural)	1.55 (1.35–1.78)	1.15 (1.09–1.21)	6215 (4077–8354)	2057 (1289–2825)



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Distributing Disease Burden from county to municipality level: Developing a model for scaling Global Burden of Disease results to local contexts

Background

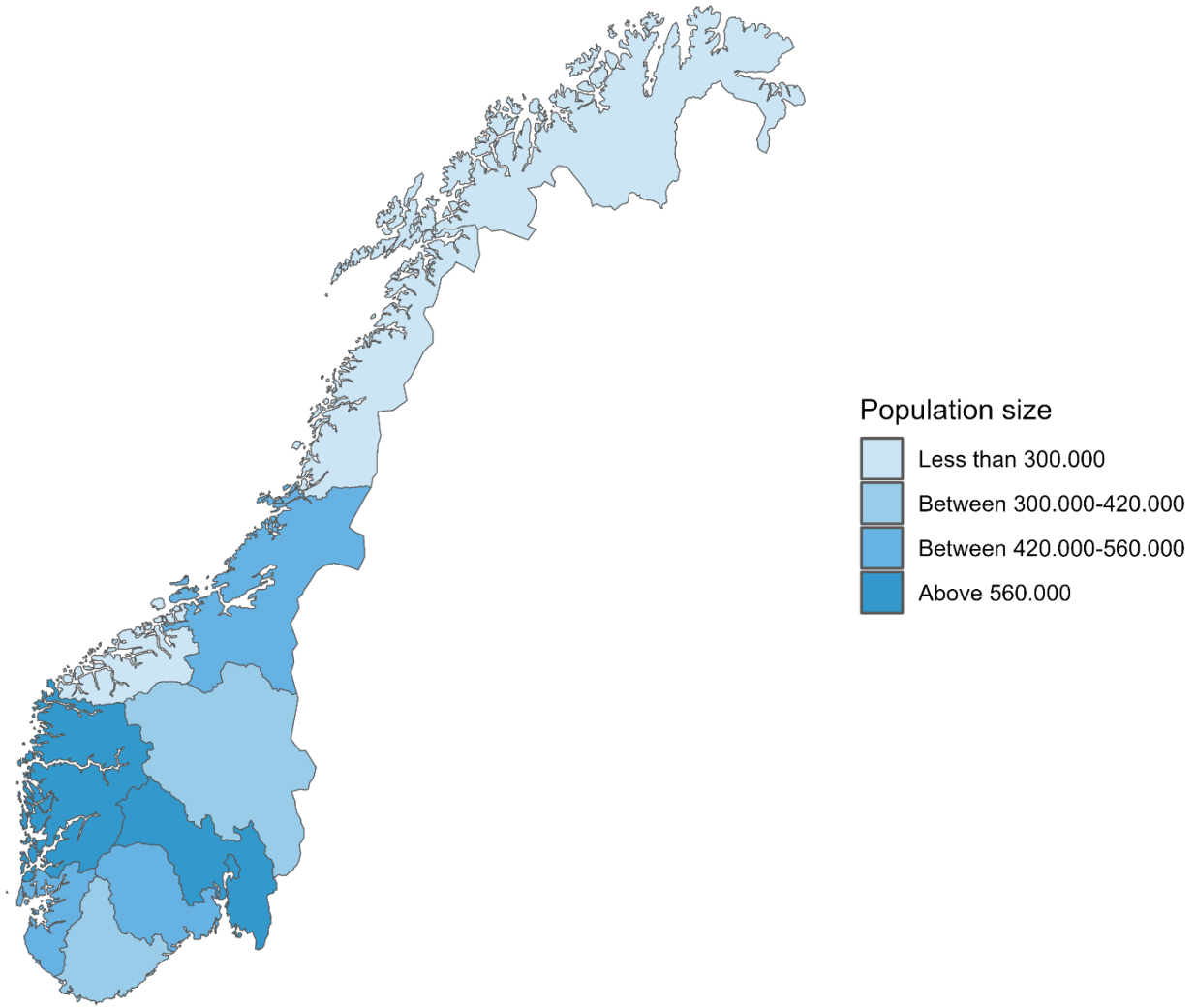
Global Burden of Disease project

- Disease burden estimates, such as those provided by GBD, are valuable but often lack detailed geographic data.
- Yet local governments are increasingly tasked with targeted health interventions and resource planning.

> *Section 5 of the Public Health Act (Folkehelseloven § 5): Municipalities shall have an overview of the health status of the population and the positive and negative factors that may affect this”*

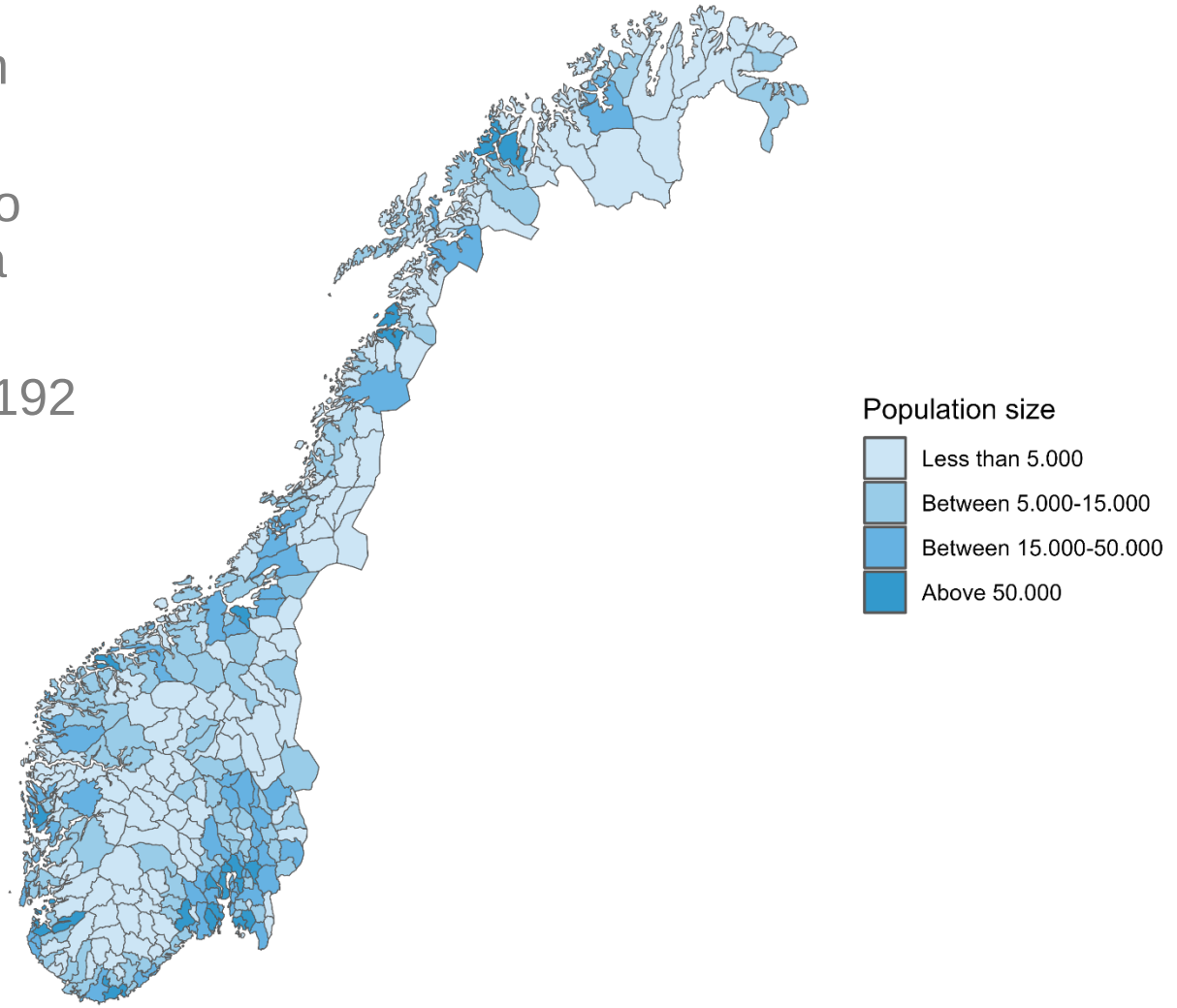
Setting: Norway

- The GBD produce estimates on subnational level for Norway by age groups * sex
- In GBD 2021/2023 there are 11 Norwegian counties with estimates.



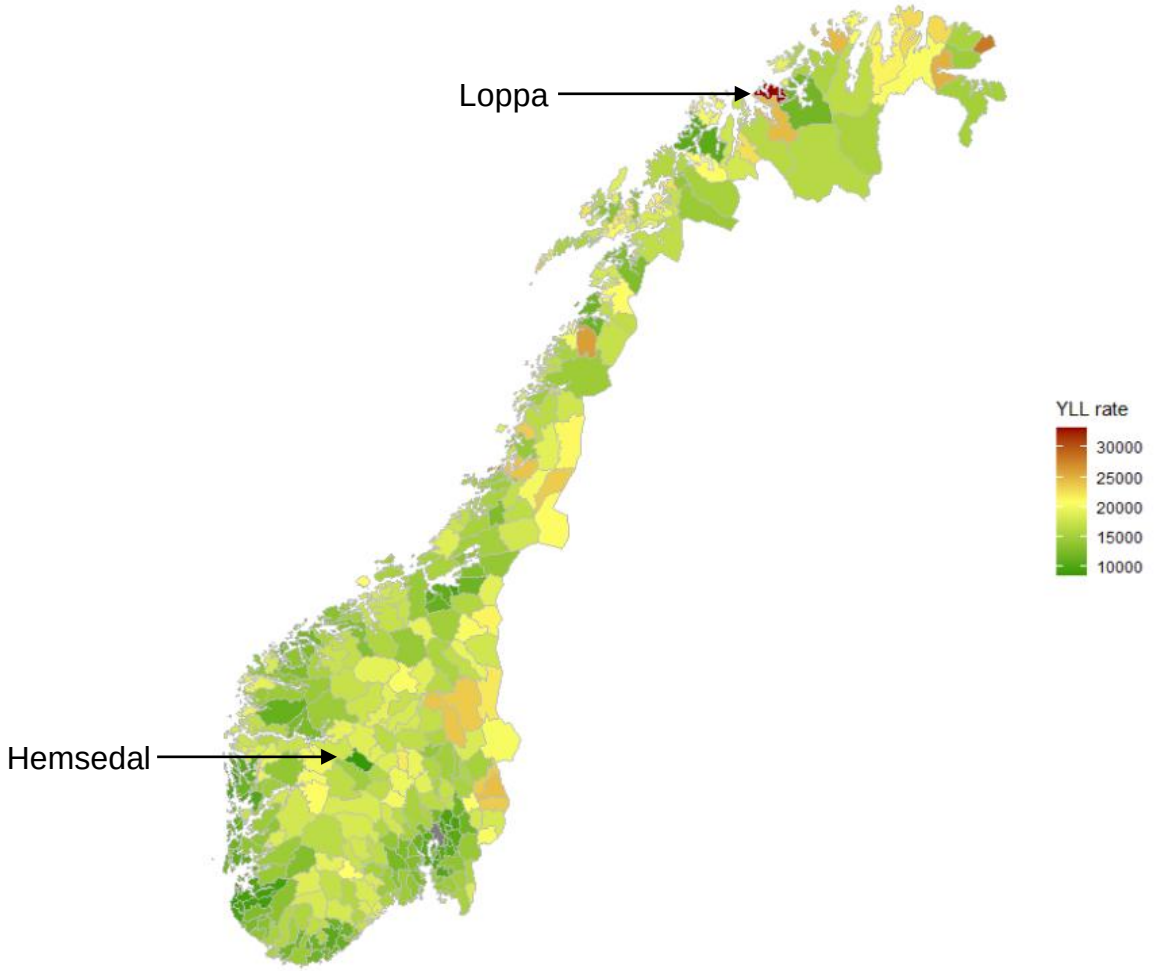
Setting: Norway

- We aimed to redistribute GBD-estimates from counties to the municipalities.
- The number of municipalities range from 23 to 51 per county (excluding Oslo which is both a county and a municipality).
- The population per municipality ranged from 192 (Utsira) to 697.010 (Oslo) with an average of 15.144 in 2021.
- A total of 279 (78,4%) municipalities had a population below the mean.



Methods and data

- YLLs were calculated using data from Norwegian population-based registries (2015-2019).
- The number of municipalities ranges from 23 to 51 per county (excluding Oslo which is both a county and a municipality) – a total of 355.
- The observed YLL-rate per 100,000 ranged from 7,843 (Hemsedal) to 36,370 (Loppa) with an average of 16,137 in the period 2015-2019.



Validation

- Tested several models vs. naïve model
- Green shows where the model best matches observed vs. predicted values.
- The naive model perform well, but the highest max difference (95,7%).
- XGBoost and LightGBM were the best models without tuning.
- They matched observed vs. predicted YLLs in 12 of 43 municipalities (28%).
- They also had the lowest max difference (43,9%), a strong result before tuning.

Municipality	Population	Deaths	YLL	Models											
				Naïve model	Zero-Inflated Poisson	Gaussian	Poisson	Negative Binomial	Hurdle	GAM	XGBoost	Random Forest	LightGBM	BRMS	GLMNET	Ensemble
4601 Bergen	288300	1976	33835	3,9 %	2,6 %	3,0 %	3,9 %	3,9 %	3,9 %	4,0 %	3,7 %	41,0 %	3,7 %	25,8 %	25,4 %	7,9 %
4626 Øygarden	39091	225	3891	4,7 %	11,2 %	10,4 %	4,7 %	4,7 %	4,7 %	4,9 %	22,3 %	63,3 %	22,3 %	45,8 %	45,4 %	19,7 %
4631 Alver	29627	192	3049	16,2 %	18,5 %	17,5 %	16,2 %	16,2 %	16,2 %	16,8 %	18,3 %	58,9 %	18,3 %	43,2 %	42,9 %	23,5 %
4627 Askøy	29948	177	3109	1,4 %	4,9 %	3,7 %	1,4 %	1,4 %	1,4 %	0,8 %	17,3 %	56,5 %	17,3 %	41,8 %	41,4 %	13,8 %
4602 Kinn	17277	177	2861	21,6 %	22,1 %	23,6 %	21,6 %	21,6 %	21,6 %	21,7 %	26,5 %	0,8 %	26,5 %	9,4 %	9,6 %	19,5 %
4624 Bjørnafjorden	25249	153	2364	21,5 %	25,1 %	24,7 %	21,5 %	21,5 %	21,5 %	21,7 %	30,0 %	74,3 %	30,0 %	58,4 %	58,0 %	32,8 %
4621 Voss	15923	151	2542	7,7 %	12,4 %	11,1 %	7,7 %	7,7 %	7,7 %	7,6 %	23,7 %	3,7 %	23,7 %	5,9 %	6,1 %	10,9 %
4647 Sunnfjord	22276	138	2144	22,1 %	23,2 %	23,4 %	22,1 %	22,1 %	22,1 %	22,4 %	26,5 %	70,0 %	26,5 %	54,9 %	54,5 %	31,5 %
4617 Kvinnherad	13168	133	2127	8,6 %	12,7 %	11,7 %	8,6 %	8,6 %	8,6 %	8,9 %	24,6 %	2,3 %	24,6 %	6,7 %	6,8 %	11,8 %
4618 Ullensvang	11041	131	1884	3,6 %	10,3 %	9,9 %	3,6 %	3,6 %	3,6 %	3,9 %	28,7 %	2,4 %	28,7 %	11,5 %	11,6 %	11,5 %
4614 Stord	18876	126	2310	3,9 %	1,8 %	1,7 %	3,9 %	3,9 %	3,9 %	3,6 %	0,5 %	33,6 %	0,5 %	22,4 %	22,1 %	4,0 %
4649 Stad	9619	108	1447	2,4 %	7,0 %	5,8 %	2,4 %	2,4 %	2,4 %	2,5 %	19,1 %	10,0 %	19,1 %	0,8 %	0,6 %	5,5 %
4613 Bømlo	12091	92	1539	3,0 %	3,3 %	4,2 %	3,0 %	3,0 %	3,0 %	2,7 %	4,4 %	28,8 %	4,4 %	18,9 %	18,6 %	2,2 %
4640 Sogndal	12029	85	1288	13,0 %	12,5 %	15,2 %	13,0 %	13,0 %	13,0 %	13,0 %	13,7 %	53,0 %	13,7 %	41,4 %	41,0 %	20,5 %
4622 Kvam	8524	69	945	38,7 %	30,2 %	32,7 %	38,7 %	38,7 %	38,7 %	38,5 %	9,8 %	49,5 %	9,8 %	36,9 %	36,7 %	31,4 %
4630 Osterøy	8174	63	1009	6,9 %	4,4 %	5,7 %	6,9 %	6,9 %	6,9 %	7,1 %	1,4 %	33,2 %	1,4 %	23,3 %	23,0 %	9,1 %
4650 Gloppen	5911	61	885	0,1 %	5,3 %	3,9 %	0,1 %	0,1 %	0,1 %	0,1 %	18,7 %	10,6 %	18,7 %	1,8 %	1,6 %	3,8 %
4648 Bremanger	3630	55	743	13,1 %	21,2 %	19,6 %	13,1 %	13,1 %	13,1 %	13,4 %	40,5 %	18,1 %	40,5 %	25,4 %	25,5 %	22,6 %
4643 Årdal	5210	49	791	4,9 %	0,2 %	0,1 %	4,9 %	4,9 %	4,9 %	4,7 %	19,8 %	9,5 %	19,8 %	0,4 %	0,3 %	1,7 %
4651 Stryn	6928	48	739	31,2 %	24,8 %	29,0 %	31,2 %	31,2 %	31,2 %	29,6 %	14,1 %	54,5 %	14,1 %	42,7 %	42,4 %	30,0 %
4611 Etne	4080	48	682	10,6 %	15,9 %	14,3 %	10,6 %	10,6 %	10,6 %	10,5 %	27,2 %	1,0 %	27,2 %	8,4 %	8,6 %	13,9 %
4628 Vaksdal	3938	46	594	7,4 %	1,8 %	1,3 %	7,4 %	7,4 %	7,4 %	7,3 %	19,3 %	10,4 %	19,3 %	1,3 %	1,1 %	0,7 %
4638 Høyanger	4072	44	677	1,2 %	7,5 %	8,7 %	1,2 %	1,2 %	1,2 %	1,3 %	26,8 %	0,1 %	26,8 %	8,3 %	8,4 %	8,9 %
4645 Askvoll	3013	43	593	10,6 %	18,2 %	16,0 %	10,6 %	10,6 %	10,6 %	10,9 %	38,1 %	15,1 %	38,1 %	22,4 %	22,5 %	19,9 %
4644 Luster	5247	42	552	40,2 %	32,5 %	36,4 %	40,2 %	40,2 %	40,2 %	40,2 %	15,7 %	57,2 %	15,7 %	45,1 %	44,8 %	35,9 %
4625 Austevoll	5315	41	712	10,5 %	9,0 %	8,7 %	10,5 %	10,5 %	10,5 %	10,0 %	9,1 %	22,1 %	9,1 %	14,2 %	13,9 %	3,6 %
4612 Sveio	5823	39	784	14,1 %	11,3 %	12,3 %	14,1 %	14,1 %	14,1 %	13,7 %	9,6 %	21,3 %	9,6 %	13,6 %	13,3 %	5,8 %
4639 Vik	2631	38	514	8,3 %	17,4 %	14,9 %	8,3 %	8,3 %	8,3 %	8,4 %	37,7 %	14,2 %	37,7 %	21,8 %	21,9 %	18,5 %
4646 Fjaler	2843	36	509	18,2 %	21,8 %	19,8 %	18,2 %	18,2 %	18,2 %	18,3 %	32,0 %	7,7 %	32,0 %	14,4 %	14,6 %	20,2 %
4642 Lærdal	2127	26	455	29,1 %	31,4 %	31,3 %	29,1 %	29,1 %	29,1 %	29,8 %	43,1 %	22,7 %	43,1 %	28,4 %	28,5 %	31,8 %
4635 Gulen	2296	25	350	5,4 %	1,7 %	1,1 %	5,4 %	5,4 %	5,4 %	5,0 %	20,1 %	9,0 %	20,1 %	0,4 %	0,2 %	1,6 %
4615 Fitjar	3182	24	391	2,4 %	0,7 %	2,3 %	2,4 %	2,4 %	2,4 %	2,6 %	0,9 %	33,1 %	0,9 %	24,8 %	24,4 %	5,2 %
4616 Tysnes	2929	23	306	51,4 %	43,6 %	49,7 %	51,4 %	51,4 %	51,4 %	50,7 %	16,5 %	58,8 %	16,5 %	46,3 %	46,1 %	42,8 %
4632 Austrheim	2893	19	306	33,4 %	32,7 %	32,4 %	33,4 %	33,4 %	33,4 %	33,2 %	15,1 %	55,7 %	15,1 %	44,8 %	44,5 %	32,8 %
4620 Ulvik	1073	16	228	18,8 %	25,5 %	24,4 %	18,8 %	18,8 %	18,8 %	18,9 %	42,7 %	21,5 %	42,7 %	28,0 %	28,0 %	26,2 %
4623 Samnanger	2513	15	251	46,7 %	41,8 %	41,3 %	46,7 %	46,7 %	46,7 %	45,9 %	21,9 %	65,4 %	21,9 %	53,4 %	53,2 %	43,0 %
4641 Aurland	1779	14	233	11,7 %	5,6 %	6,7 %	11,7 %	11,7 %	11,7 %	10,9 %	7,1 %	26,2 %	7,1 %	17,1 %	16,8 %	9,1 %
4634 Masfjorden	1683	12	145	95,7 %	81,9 %	82,6 %	95,7 %	95,7 %	95,7 %	96,0 %	41,3 %	93,7 %	41,3 %	77,7 %	77,4 %	79,5 %
4636 Solund	783	12	170	22,9 %	26,5 %	26,0 %	22,9 %	22,9 %	22,9 %	23,2 %	43,9 %	23,4 %	43,9 %	29,4 %	29,5 %	28,5 %
4637 Hyllestad	1313	11	176	25,0 %	19,7 %	20,3 %	25,0 %	25,0 %	25,0 %	23,8 %	9,2 %	24,0 %	9,2 %	14,3 %	14,2 %	15,6 %
4619 Eidfjord	918	11	158	12,0 %	15,1 %	13,5 %	12,0 %	12,0 %	12,0 %	12,6 %	29,3 %	3,7 %	29,3 %	11,0 %	11,2 %	14,7 %
4633 Fedje	533	7	97	9,6 %	3,6 %	2,9 %	9,7 %	9,7 %	9,7 %	9,5 %	33,1 %	7,1 %	33,1 %	16,1 %	16,1 %	6,4 %
4629 Modalen	472	3	53	10,9 %	10,8 %	16,1 %	10,9 %	10,9 %	10,9 %	10,4 %	8,4 %	46,2 %	8,4 %	35,4 %	35,2 %	18,9 %

The One Model to Rule Them All

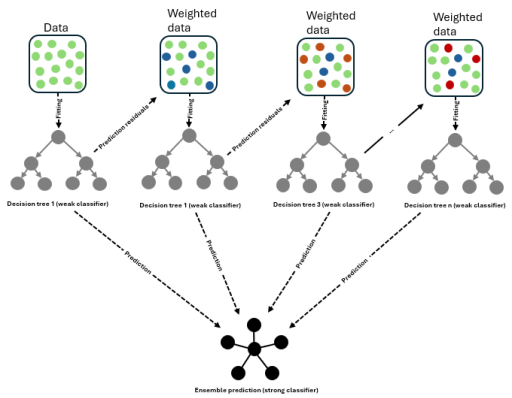
One model to **rule** them all

One model to **find** them

One model to **bring** them all

And in data **bind** them





- A machine learning method that builds many decision trees.
- Each tree learns from the mistakes of the previous ones.
- Very accurate, fast, and avoids overfitting.

Other covariates

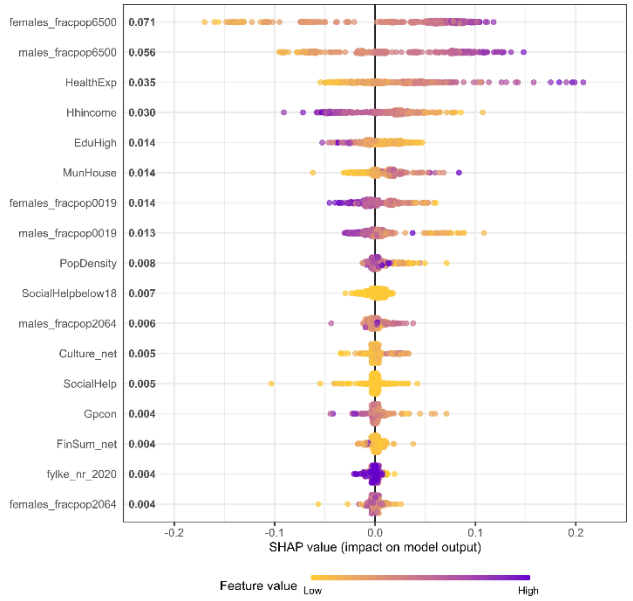
- We included several predictors with municipality-level information
  - Urban areas
  - Higher education (165y +)
  - % household income above the median
  - No. of GP consultations per person
  - Health expenditures per person
  - % receiving social welfare benefits
  - Social housing per 1000 of the population
  - Cultural expenditures per person
  - Net expenditures for the municipality

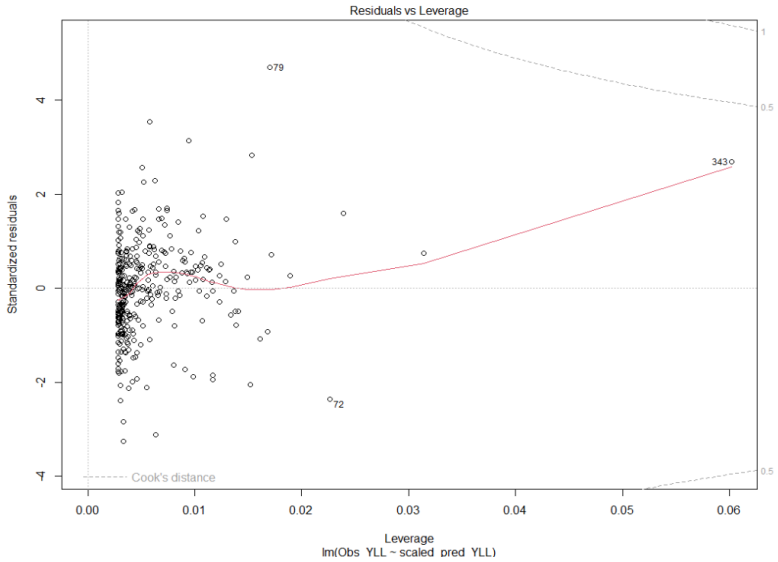
Results

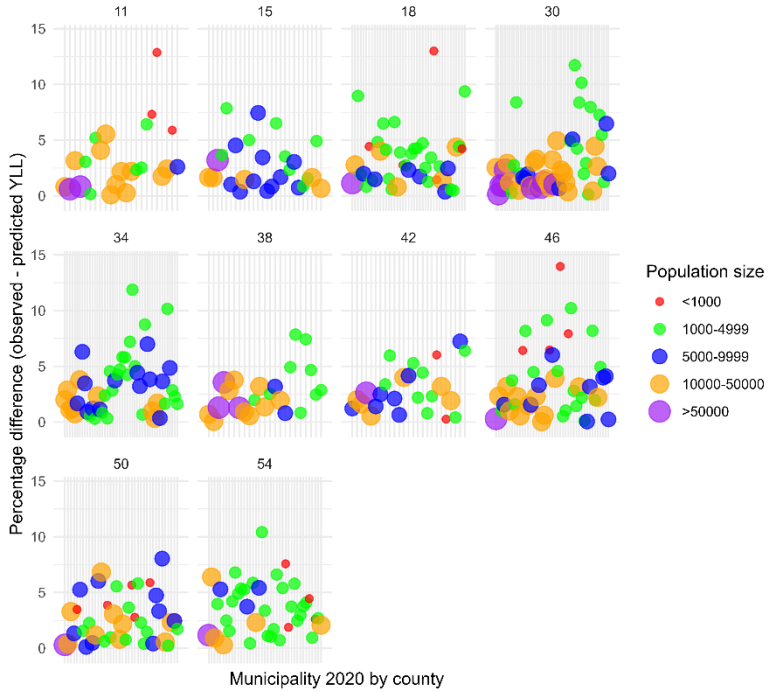
- The final model, with additional covariates, achieved an average prediction error of 3% and an R^2 of 0.97
- The five municipalities with the highest errors had prediction differences ranging from 12% to 14%.
  - 4633 Fedje had the highest prediction error with 14%.
  - This corresponds to 81 YLLs observed and 93 YLLs predicted.
- A reduced version of the model, using only demographic data, performed significantly worse, with prediction errors reaching up to 30%.
- When tested on observed YLLs from a holdout year not included in the model training (2021), the model demonstrated similar performance, with a maximum prediction error of approximately 17%.

Results

- Despite a relatively low max prediction error of 14%, the model showed its greatest errors in small-population municipalities.
- Features related to elderly populations have the biggest impact, followed by health spending and income.







RESEARCH Open Access

Educational differences in years lived with disability due to mental and substance use disorders: a cohort study using nationwide Norwegian and Danish registries

Nanna Oerslev Weye[1,2], Oleguer Plana-Ripoll[1,3], Carl Michael Baravelli[6], Emilie E. Agardh[4], Lode van der Velde[4], Jonas Minet Kinge[5,6] and Ann Kristin Skrindo Knudsen[6*]

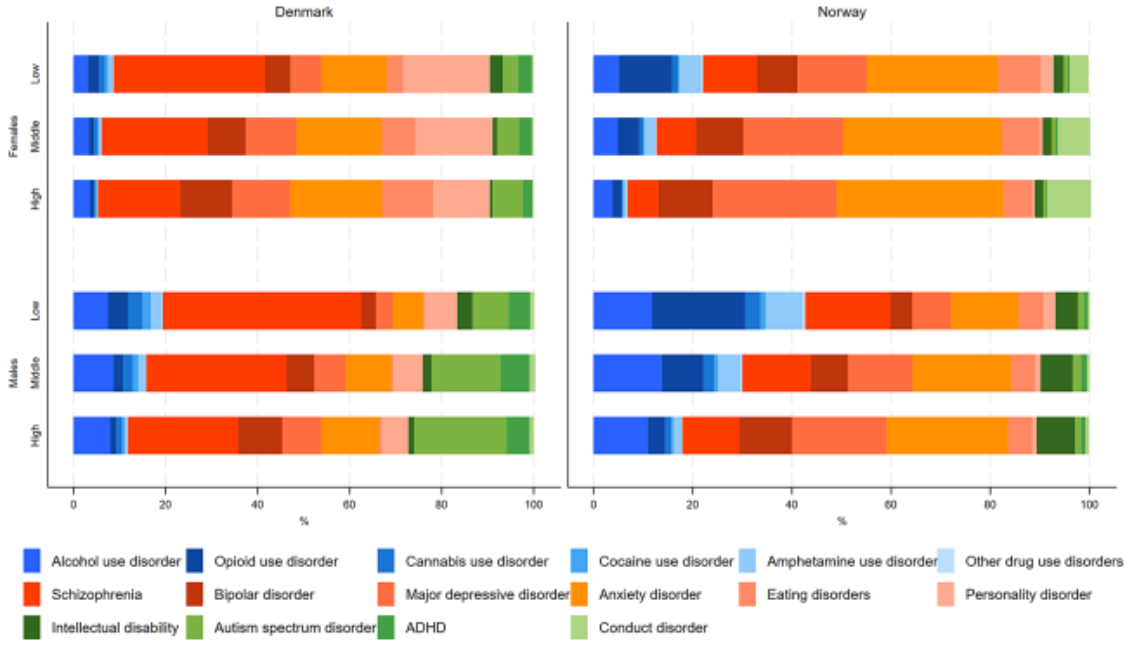


Fig. 5 Proportion of total years lived with disability (YLDs) for mental disorders attributed to specific mental disorders by educational level among patients registered in secondary health care in Denmark and Norway

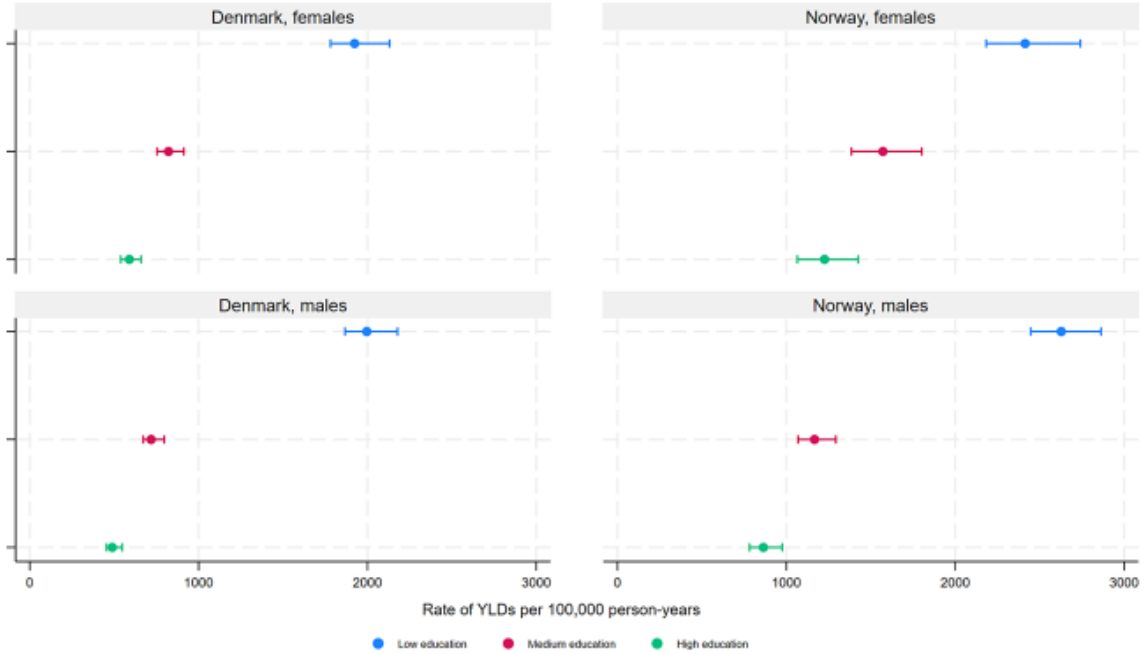


Fig. 1 Years lived with disability due to any mental or substance use disorder by educational level, among patients registered in secondary health care in Denmark and Norway

Thank you