ever working night shifts (p = 7.3 × 10⁻⁸). There was nominal evidence for an inverse association between current shift and rotating work with accelerated ageing (EAA) (mean difference = -0.98 (-1.93, -0.39); p = 0.041 and -1.11 (-2.19, -0.04); p = 0.041, respectively).

Conclusion Shift work was associated with differential methylation in blood, including a CpG site in PPARG. This CpG site is specific to the Illumina EPIC array, not being present on the predecessor 450 K array, and represents a potentially novel finding. PPARGamma has been implicated in the pathology of obesity, diabetes and cancer, although further work is required to appraise the causal effect of methylation on health outcomes. Furthermore, there was some evidence that current shift workers had decelerated methylation age compared with non-shift workers. However, the number of shift workers in this study was relatively small and further validation of findings is required.

Results SEP, smoking, physical activity, obesity, occupational exposures and air pollution were associated with lung function. Interaction terms indicated a stronger association between disadvantaged childhood SEP and currently smoking (coefficient (_b_) = -6.506%, 95% confidence intervals (95% CI): -9.361%, -3.451%), formerly smoking (b = -2.331% 95% CI -3.674%, -0.988%) and occupational exposures, (b = -1.436% 95% CI -2.725%, -0.147%). Significant interactions were not found with physical activity, obesity, ETS and air pollution.

Conclusion The findings suggest that disadvantaged SEP in childhood may make people more susceptible to the negative effect of smoking and occupational exposures in adulthood. This is important as those most likely to encounter these exposures are at greater risk to their effects. Policy to alleviate this inequality requires intervention in health behaviours and via health and safety legislation.

Background Lung function is lower in people with disadvantaged socio-economic position (SEP) and is associated with certain health behaviours and exposures. The effects are likely to be interactive, for example socially patterned environmental tobacco smoke (ETS) in childhood is associated with an increased effect of smoking in adulthood. We hypothesise that disadvantaged childhood SEP increases susceptibility to the effect of hazards for lung function in adulthood. We test whether disadvantaged childhood SEP moderates smoking, physical activity, obesity, occupational exposures, ETS and air pollution’s associations with lung function.

Methods Data are from the Nurse Health Assessment (NHA) in waves two and three of United Kingdom Household Longitudinal Study (UKHLS). The NHA is drawn from the UKHLS General Population Sample, a stratified, clustered, equal probability sample, and from the British Household Panel Survey sample which began in 1991 as a stratified random sample. Analysis is restricted to English residents aged at least 20 for women and 25 for men; an analytical sample of 16 328. Lung function is measured with forced expiratory volume in the first second (FEV1) and standardised to the percentage of expected FEV1 for a healthy non-smoker of equivalent age, gender, height and ethnicity (FEV1%). A multilevel approach was used with individuals nested in households in neighbourhoods. Using STATA14, a mixed linear model was fitted with interaction terms between childhood SEP and health behaviours and occupational exposures. Cross level interactions tested whether childhood SEP moderated household ETS and neighbourhood air pollution’s associations with FEV1%.

Background Reducing the number of young people not in employment, education or training (NEET) is high in political agenda in many countries. The Europe 2020 flagship initiative Youth on the Move introduce a number of programmes that tackle this problem. Although NEET young people have been identified as one of the most vulnerable groups since the 1990s, little is known about the long-term effect of NEET experiences, especially the health consequences. This paper investigates whether experiences of NEET young people are associated with poor health.

Methods We used the Scottish longitudinal study (SLS), which collates information from the 1991, 2001, and 2011 censuses as well as from vital events, for a 3.3% representative sample of the Scottish population. Linked health data such as hospital admissions and prescribing in general practice are also available. We followed around 14 000 young people who were aged 16–19 in 1991 up to 2010. We explored whether NEET young people in 1991 displayed higher risks of poor physical and mental health in the follow-up period. Three health outcomes are used in the analysis: mortality, hospitalisation and prescription of anti-depressant and anti-anxiety medication. We used logistic regression to model the probability of hospitalisation and poor mental health. We fitted a Cox proportional hazards model to model time to death. Covariates include a number of individual socioeconomic characteristics and local area characteristics.

Results Over 40% of the cohort members have been admitted into hospital, while over 15% have been prescribed with anti-depressant and anti-anxiety drugs, and 1% died in the follow-up period. The NEET status in 1991 appears to be associated with hospitalisation with adjusted odds ratio (OR) of 1.24 (95% Confidence Intervals (CIs): 1.08–1.42). Also the NEET experiences are associated with poor mental health with OR of 1.47 (95% CI 1.27 to 1.71). The hazard ratio of death for NEETs is more than twice that for non-
NEETs (HR: 2.5, 95% CI 2.2 to 2.9). The elevated risk remained even when the models were fitted separately by gender.

**Conclusion** We found that NEET experiences are associated with elevated risks of mortality, hospitalisation and poor mental health. Disengagement from employment and education during transition from school to work may lead to long term negative health effects which in turn results in social and economic costs to society. Policy intervention is necessary in assisting NEET young people to re-engage in education or employment.

**P11**

**MATHEMATICAL COUPLING AND CAUSAL INFERENCE THROUGH EXAMPLE**

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**Background** In health studies, proportions and percentages can often seem more informative than raw counts and therefore appear to be of more interest to analysts. However, it has long been acknowledged that their use is problematic in correlation and regression analyses where they comprise common components that are present in both the dependent and independent constituents of a model (exposure and outcome), as in the regression analysis of proportions with common denominators. We demonstrate this so-called mathematical coupling with real-world examples aided by directed acyclic graphs (DAGs) and simulations.

**Methods** We consider three possible real-world scenarios: (1) the population size (N) of a geographical area causes both the number of people living in detached houses (X) and the number of people living in care homes (Y), within each area, but the number of detached houses (X) does not cause the number of care homes (Y) within any area, or vice versa; (2) the population size (N) of a geographical area causes both the number of people with no formal qualifications (X) and the number of people with poor self-reported health (Y), while both the population size (N) and number of people with no formal qualifications (X) are causes of the number of people with self-reported poor health (Y); and (3) within a geographical area, the area wealth (X) causes the number of elderly people (N), while both area wealth (X) and the number of elderly people (N) cause social care expenditure (Y).

**Results** We show how historical solutions to the issue of mathematical coupling caused by a common denominator hold under the situation when the denominator is a confounder of the exposure outcome relationship; i.e. the results of the simulated examples under scenarios 1 and 2 result in expected regression coefficients. The same solution does not hold in scenario 3, when the denominator is a mediator (i.e. lies on the causal path) between the exposure and outcome.

**Conclusion** We show how DAGs and accompanying causal graph theory can be used to understand a problem first presented over a century ago. We highlight the issue of mathematical coupling when analysing proportions with a common denominator, showing under which circumstances historical solutions are valid or invalid. By using real-world examples to inform simulations, we demonstrate the utility of DAGs and causal graph theory in health geography and observational research to understand statistical problems and to verify proposed solutions.