mortality counts using adjusted rates for national and regional DuPont worker populations. Robust specification of priors will be sought. Implementation of the calculations will be developed in common software.

Conclusions We plan to develop a method for SMR calculation that accounts for the healthy worker selection effect both in the point estimate and uncertainty interval.

0310 NAPPING DURING NIGHT SHIFT AND SELF-REPORTED HYPERTENSION AMONG NURSING WORKERS

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Objectives Night and shift work are suggested risk factors for hypertension. Considering the relationship between sleep deprivation and blood pressure, this study focuses on self-reported hypertension and napping during night shift. Our aims are (1) to analyse the prevalence of hypertension among day and night workers and (2) to test the association between napping regularly during night shifts and prevalence of hypertension among night workers.

Method This cross sectional questionnaire study was carried out at 18 public Brazilian hospitals in 2010–2011 (N=3229 registered nurses). Only women workers were included in the analysis (N=1992). Statistical treatment of data was carried out in two steps: (i) assessing self-reported hypertension considering work schedule and (ii) analysing nap habits during night shifts and self-reported hypertension.

Results Mean age was 39.9 (SD= 10) years. Napping during the night shift (for up to three hours) increased the odds of self-reported hypertension 1.8-fold (95% CI 1.36–2.45) compared with day workers with no experience on night shifts, after adjusting for age, physical activity, smoking habits, and housework. Among night workers, sleeping during the night shift reduced the odds of reporting hypertension (OR=0.79; 95% CI 0.63–1.00), compared to those who reported not to sleep during the night shifts.

Conclusions The higher prevalence of hypertension among shift workers was confirmed. Dipping patterns and blood pressure control may be influenced by short periods of sleep in night shifts. The potential positive effect of naps on blood pressure deserves further investigation through automatic monitoring.

0341 COUNTERFACTUALS, QUANTUM MECHANICS AND G-ESTIMATION: CAUSALITY THREATENS EPIDEMIOLOGY

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Objectives Causal reasoning should have an explicit formal structure.

Method Such a structure can be provided with the help of counterfactuals. This approach allocates different versions (factual and non-factual) of exposures and responses to every basic study unit (e.g., a subject observed at one point of time). Comparisons of these versions within the unit imply causal statements about the effect of exposures. This approach may appear unusual and strange but it is consistent to basic principles of modern physics (superposition principle of quantum mechanics).

Results The outline of causality in counterfactual terms is helpful to solve problems like defining and measuring direct and indirect causal paths or to specify biases and adjusting procedures. In contrast to experimental research observational studies (like those performed in epidemiology) suffer from missing randomization. A causal concept is important to understand the reliability of such studies: a strict counterfactual framework motivates to analyse observational studies in terms of generalised treatments ("G"). G-estimation is a procedure that defines the causal effect estimates on the individual level by counterfactual failure times. Causal models are nested within estimating models ("structurally nested failure time models").

Conclusions Such a strict counterfactual reasoning challenges standard estimators and estimating procedures usually applied in epidemiology.

0348 THE HEALTHY WORKER SURVIVOR EFFECT DISSECTED: ADDRESSING COMPONENT PARTS

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Objectives The healthy worker survivor effect (HWSE) is a well-recognised bias usually described as a form of selection bias or confounding. A more precise epidemiologic explanation, however, has been elusive. We distinguish several components of the HWSE and suggest methods for bias correction in occupational cohort studies.

Method Although generally referred to a single effect, we demonstrate using simulation studies that there are in fact four distinct aspects of the HWSE. Two aspects, (1) time-varying confounding by variables on the causal pathway and (2) heterogeneity in susceptibility, are functions of the underlying process of the exposure and disease under study. The other two, (3) left truncation and (4) right truncation, are functions of how the data are collected, ie the study design. We quantify the bias induced by each aspect of HWSE on dose-response parameter estimates and apply methods designed to reduce the bias.

Results We find that causal techniques, eg, g-estimation and IPTW, can correct for time-varying confounding. Heterogeneous susceptibility in combination with either left or right truncationcan be corrected using inverse probability of censoring weights. The health related variables needed to make either of these methods succeed in reducing the bias are often unmeasured.

Conclusions HWSE occurs due to the presence of any of four factors that may function separately or in concert to produce a downward bias if not accounted for. We provide guidance for methodologic approaches to reduce the bias.

0351 G-ESTIMATION: WHY DOES IT WORK AND WHAT DOES IT OFFER?

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Objectives Standard data analysis procedures provide biassed answers to etiologic questions in occupational studies. G-estimation is an alternative that allows researchers to avoid healthy worker survivor bias, and its results can be expressed as estimates of the impacts of hypothetical policy interventions.

Method Rather than estimating the association between observed exposure and observed outcome, g-estimation models the counterfactual outcomes under no exposure as a function of observed outcomes and exposures. Adjustment for confounders is achieved by predicting exposure conditional on those confounders and on the counterfactual outcome. The method leverages the assumption that all confounders are measured: within strata of the measured confounders, observed exposure is "randomised"–that is, statistically independent of counterfactual outcome. This allows for correct adjustment for time-varying confounders affected by prior exposure and thus avoids healthy worker survivor bias.

Results Results can be expressed in terms of the impacts of hypothetical exposure limits. For example, after g-estimation of an accelerated failure time model, counterfactual survival times under a series of specified exposure limits can each be compared to observed survival time. This allows the researcher to report estimates of the total number of years of life that could have been saved by enforcing each limit.

Conclusions G-estimation is a valuable tool for occupational epidemiologists because it can both prevent bias due to the healthy worker survivor effect and estimate the impacts of hypothetical exposure limits.

0359 NIGHSHIFT WORK AND BREAST CANCER RISK – GOOD NEWS, BAD NEWS?

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Objectives Using two large prospective data sets, we explored associations between rotating nightshift work and breast cancer risk.

Method Among 193 396 women from the Nurses' Health Study (NHS and NHS2) cohorts, we documented 5575 (NHS) and 2869 (NHS2) incident invasive breast cancer cases as well as 696 (NHS) breast cancer deaths over 22 years of follow-up. Compared to our initial analysis within NHS, which was based only on 10 years of follow-up and showed that 30+ years of rotating nightshift work was associated with a 36% significant increase in breast cancer risk, we added 12 years of follow-up, which were accrued for the most part after nurses' retirement.

Results In these extended analyses, 30+ years of rotating night shift work was no longer associated with breast cancer risk (multivariable RR_{30+yrs}=0.95, 95% CI 0.77–1.17; p_{trend}=0.95), and only insignificantly associated with breast cancer mortality (multivariable HR_{30+yrs}=1.50, 95% CI, 0.95–2.36). By contrast, in the younger NHS2 cohort, baseline 20+ years of rotating nightshift work was associated with a significantly increased risk of breast cancer (RR_{20+yrs} =2.11, 95% CI 1.21–3.66; p_{trend}=0.22). Updated rotating night shift work exposure was also associated, albeit non-significantly, with a modest increase in risk of breast cancer (RR_{20+yrs}=1.33, 95% CI0.93–1.89; p_{trend}=0.68).

Conclusions Taken together, these results suggest that long-term rotating night shift work particularly early in career may be associated with an increased risk of breast cancer, which appears to diminish after nightshift work ceases. Future studies are needed to confirm these findings and should explore the potential for tailored risk factor counselling in nightshift workers.

0363 MARGINAL STRUCTURAL MODELS TO ACCOUNT FOR TIME-VARYING CONFOUNDING VARIABLE AND THE HEALTH WORKER SURVIVOR EFFECT (FOR A MINI-SYMPOSIUM ON 'DYNAMICS OF EXPOSURE AND DISEASE', ORGANISED BY VERMEULEN)

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Objectives Marginal structural models (MSMs) in longitudinal studies are needed when time-varying confounders are themselves predicted by previous exposure, and are intermediate variables on the pathway between exposure and disease. The epidemiologist is left with the unenviable choice of adjusting or not for the confounder/intermediate variable. An example would be whether aspirin decreases cardiovascular mortality, in which the confounder/intermediate variable is cardiovascular morbidity.

Method MSMs use inverse-probability weights based on an 'exposure' model which assesses the probability that each subject has received their own exposure and confounder history up to time t, with the follow-up period divided into T (t=1 to T) categories. These weights are then used in standard regression models (eg., pooled logistic regression models across T categories) relating exposure to disease. Their use creates a pseudo-population where time-varying confounding is eliminated.

Results Empirical results show that standard methods to control for time-varying confounders can result in bias towards the null, compared to MSMs. A recent simulation study showed MSMs lead to unbiased results under a variety of assumptions.

Conclusions Some studies have used somewhat different but related methods ("g-estimation") to account for the healthy worker survivor effect, where employment status is a time-varying confounder which predicts future exposure and may predict disease, but may also act as an intermediate variable because prior exposure may cause illness which results in leaving employment. Here we will present an overview of MSMs and the related g-estimation models.

0367 RATIONAL FOR CHOOSING EXPOSURE METRICS: A SHORT HISTORY

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Objectives Risk of chronic disease may be governed not only by cumulative levels of exposure but also by dynamic aspects of the exposure history. These dynamic aspects include characteristics of the exposure history itself (such as duration of exposure or time-varying intensities of exposure) as well as aspects of age-related susceptibility. This workshop will provide an overview of methods developed to better understand the dynamic aspects of exposure in epidemiological models.

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