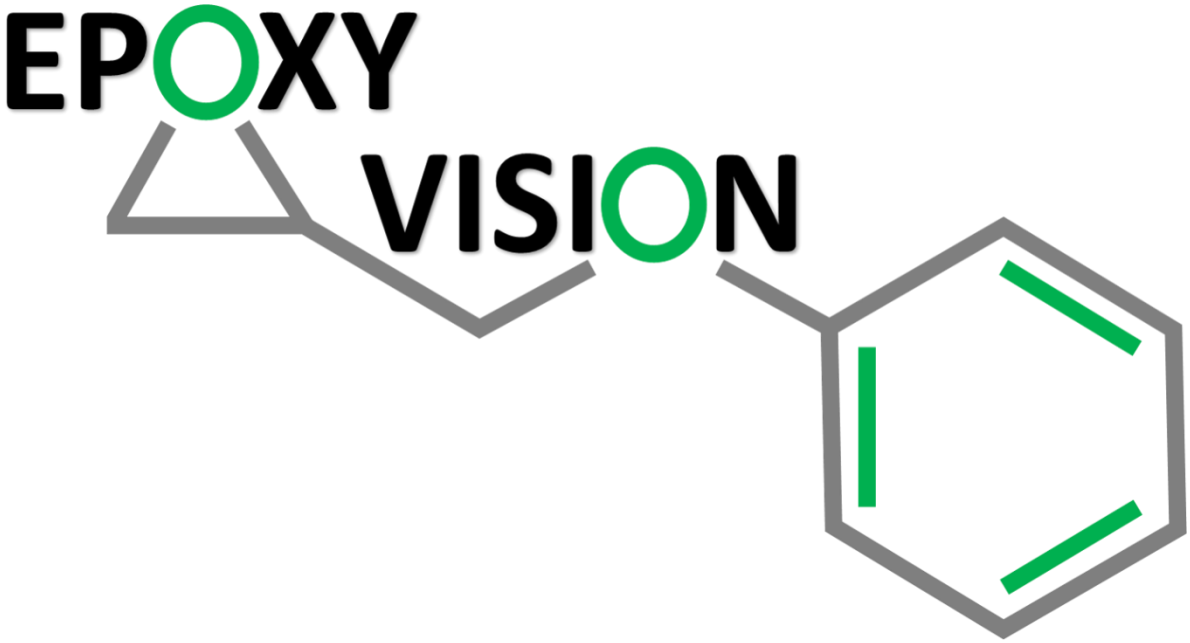
Afslutningsrapport til Arbejdsmiljøforskningsfonden

Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per Axel Clausen, Jakob Hjort Bønløkke, Vivi Schlünssen, Marléne Isaksson, Henrik Kolstad



Arbejdsmedicin, Aarhus Universitetshospital; Hud- og kønssygdomme, Aarhus Universitetshospital; Arbejdsmedicin, Regionshospitalet Gødstrup; Det Nationale Forskningscenter for Arbejdsmiljø; Institut for Folkesundhed, Aarhus Universitet; Arbejds- og miljømedicinsk Afdeling, Aalborg Universitetshospital; Yrkes och miljödermatologiska avdelingen, Skånes Universitetssjukhus

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Forord

Arbejdsmiljøforskningsfonden støttede gennemførelsen af projektet "Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering", projektnummer: 20175100924, som har løbet fra dato 1. maj 2018 til 31.december 2023.

Projektgruppen har bestået af Alexandra Golabek Christiansen, Henrik Kolstad, Arbejdsmedicin Aarhus Universitetshospital Aarhus, Mette Sommerlund, Hud- og kønssygdomme, Aarhus Universitetshospital, Ole Carstensen, Arbejdsmedicin, Regionshospitalet Gødstrup, Per Axel Clausen, Det Nationale Forskningscenter for Arbejdsmiljø, Vivi Schlünssen, Institut for Folkesundhed, Aarhus Universitet, Jakob Hjort Bønløkke, Arbejds- og miljømedicinsk Afdeling, Aalborg Universitetshospital, Marléne Isaksson, Yrkes och miljödermatologiska avdelingen, Skånes Universitetssjukhus, Malmö, Pia Christoffersen, Vestas Wind Systems A/S, Christian Libak Pedersen, Dorthe Reindahl Jahnsen, Marcus Illanes og Luise Skov Fritsche, Siemens Gamesa Renewable Energy.

Alexandra Golabek Christiansen har været PhD studerende på projektet med den engelske titel "Risk and prevention of dermatitis and skin sensitization following occupational exposure to epoxy components" med Henrik Kolstad, Ole Carstensen og Mette Sommerlund som vejledere.
Alexandra Golabek Christiansen forsvarede den 25/8 2023 Ph.d.-graden ved Health, Aarhus Universitet.

Projektets følgegruppe har bestået af Christina Busk, miljøpolitisk chef, plastindustrien, Bent Horn Andersen, chefkonsulent, DI, John Villadsen, Arbejdsmiljøkonsulent, 3F Industrigruppen, Michael Jørgensen, områdeleder, CO-Industri.

Projektet er udført i samarbejde med Vestas Wind Systems A/S og Siemens Gamesa Renewable Energy, som også har ydet økonomisk støtte til projektet.

Morten Frydenberg, Anders Majland, Mads Stisen Gjanderup, Kirsten Pugdahl, Else Toft Würtz, Martin Byskov Kinnerup, Alexander Jahn, Sigrun Alba Johannesdottir Schmidt, Karen Just, Gitte Østergaard, Michel Jungblut og Casper Seerup har alle bidraget væsentligt til projektet.

Vi retter en varm tak til de deltagende virksomheder, alle ansatte, som har deltaget i projektet, og Arbejdsmiljøforskningsfonden, som gjorde undersøgelsen mulig.

Århus 9. februar 2024,

Henrik Kolstad

Dansk resumé

Epoxy resin systemer indeholder komponenter, der er hudsensibiliserende og hyppige årsager til eksem. Høje forekomster af epoxysensibilisering og eksem har været rapporteret blandt personer, der arbejder med epoxyprodukter. Dette projekt havde til formål at undersøge forekomsten af sensibilisering og eksem blandt medarbejdere, der arbejder med epoxy i den danske vindmølleindustri. Det var også formålet, som led i en forebyggelsesstrategi, at udvikle et fluorescens-baseret visualiseringssystem til påvisning af epoxyforurening af huden.

Studie 1 var et tværsnitsstudie af medarbejdere ansat på to vindmøllevingefabrikker. Vi undersøgte forekomsten af hudsensibilisering og eksem blandt 180 epoxy-eksponerede produktionsmedarbejdere og sammenlignede dem med 41 ikke-eksponerede kontormedarbejdere. Undersøgelsen viste, at næsten 9% af de epoxy-eksponerede medarbejdere var sensibiliserede over for komponenter i de epoxyprodukter de benyttede, sammenlignet med ingen af kontormedarbejderne. Risikoen for sensibilisering faldt med eksponeringens varighed forenelig med stærk *healthy worker survival bias*. Hyppigheden af eksem var forhøjet blandt produktionsarbejdere uden atopisk eksem i barndommen.

Studie 2 var en registerbaseret follow-up undersøgelse af 825 epoxy-eksponerede produktionsmedarbejdere, 1091 ikke-eksponerede produktionsmedarbejdere og 493 kontormedarbejdere fra én af de to fabrikker, der indgik i studie 1. Arbejdspladsoplysninger om eksponeringer blev kombineret med oplysninger fra nationale registre om eksemdiagnoser stillet på hospitaler, udførte lappetests, konsultationer ved privatpraktiserende dermatologer og indløsning af recepter på binyrebarkhormon (den primære behandling for eksem). Undersøgelsen viste forøget risiko for eksem blandt de epoxy-eksponerede produktionsarbejdere og faldende risiko med stigende eksponeringsvarighed. Resultaterne var således i overensstemmelse med studie 1.

Studie 3 omhandlede udviklingen af et system til synliggørelse af epoxyeksponering af huden. Vi brugte et kommercielt tilgængeligt epoxyprodukt tilsat fluorescerende sporstof. Systemet belyser brugerne med ultraviolet stråling (UVA) og de fluorescerende områder, hvor huden er epoxy-eksponeret, vises på en skærm. For hver kropsdel registreres omfanget af de eksponerede områder baseret på antallet af pixels registreret af et digitalkamera. Systemet er i stand til at finde dråber ned til en størrelse på 1 mm og forventes også at være anvendeligt i industrier, hvor der benyttes andre kemikalier med risiko for hudeksponering.

English summary

Components of epoxy resin systems are well-known skin sensitizers and common causes of allergic contact dermatitis. High prevalences have been reported among epoxy-exposed workers. In Denmark, considerable attention has been devoted to regulation, education, new procedures and protective equipment. This project aimed to examine the risk and prevalence of sensitization and dermatitis among epoxy-exposed workers using comprehensive protective equipment. Furthermore, to develop a computerized fluorescence-based system for measuring epoxy contamination of the skin to increase worker alertness and prevent repeated and prolonged skin exposure.

Study 1 was a cross-sectional study at two wind turbine blade factories examining the prevalence of skin sensitization and dermatitis among 180 highly epoxy-exposed production workers compared with 41 non-exposed office workers. The study showed that almost 9% of epoxy-exposed workers were sensitized to epoxy components compared with none of the non-exposed. The risk decreased by duration of exposure in line with strong healthy worker survival bias. Among non-atopic workers, the prevalence of dermatitis was higher among production than among office workers.

Study 2 was a register-based follow-up study of 825 epoxy-exposed blue-collar workers, 1091 non-exposed blue-collar workers and 493 white-collar workers from one of the two factories included in study 1. Workplace information on exposure was combined with national register information on dermatitis that was defined as a hospital-diagnosis of dermatitis, consulting a private dermatology clinic, a patch test or filling a prescription for topical corticosteroids. The study showed increased incidence rate ratios of dermatitis following epoxyexposure as well as declining rate with duration of exposure. Findings are thus in line with study 1.

Study 3 reports the development of a system for detection of skin exposure to epoxy resins with a fluorescent tracer added. The system illuminates the users with ultraviolet radiation and the fluorescent areas are displayed on a monitor. For each body part, the exposed areas are quantified based on the number of pixels recorded by a digital camera. The system is able to detect droplets down to a size of 1 mm and is expected to be applicable in industries with risk of skin exposure to other chemicals as well.

Baggrund

Epoxyplast er materialer med stor styrke, fleksibilitet og isolerende egenskaber. De bruges industrielt i vidt omfang, specielt som beskyttende overflader, i lim og maling, ved fremstillingen af kompositter fx i vindmøllevinger, og som et stærkt bindemiddel for kulfiber, glasfiber, træ og andre materialer. Epoxyplast fremstilles af epoxyresin (epoxyharpiks), hærder (alifatiske aminer, polyaminer, polyamider, syreanhydrider), reaktive fortyndere samt eventuelle tilsætningsstoffer (1, 2). Når komponenterne blandes, reagerer de med hinanden under dannelsen af en plast. 75-90 % af epoxyresinerne er baseret på diglycidylether af bisphenol A (DGEBA) (3).

Det primære helbredsproblem ved arbejde med epoxy komponenter, er allergisk kontakteksem. Allergisk kontakteksem er en inflammatorisk sygdom, som oftest er lokaliseret til huden på hænder, underarme og i ansigtet. Sygdommen er kendetegnet ved rødme, blærer, afskalning og revner i huden og kan kompliceres af bakterielle infektioner (4). Allergiske kontakteksemer skyldes en forsinket allergisk type IV reaktion ved kontakt med et allergen fx epoxy komponenter. Den allergiske reaktion kræver forudgående hudsensibilisering gennem ofte kortvarig kontakt med det pågældende allergen og ved efterfølgende eksponering opstår der en inflammatorisk reaktion (5). Behandlingen af eksemet er som regel, i første omgang, anvendelse af binyrebarkhormoncreme.

Man påviser primært årsager til allergiske eksemer ved lappetestning med et standard testpanel, Europæisk Standard Lappetest (ESL), suppleret med enkeltallergener og specifikke produkter, som man har under mistanke (6). Hvis de sidstnævnte produkter ikke medtages i testen, er der risiko for at overse allergi (7-9).

Det er velkendt at DGEBA, andre epoxy resiner (fx diglycidylether af bisphenol F, DGEBF), hærdere (alifatiske, cycloalifatiske og aromatiske aminer), tilsætningsstoffer (fx 1,6-hexanediol diglycidyl ether) og andre bestanddele i epoxyprodukter kan medføre hudsensibilisering (10-13). Et tidligere studie viste, at mellem 10-15 % af arbejdsrelaterede kontakteksemer skyldes eksponering for epoxyresin (14). I et dansk studie fandt man, at epoxy resin var den næst hyppigste årsag til arbejdsbetinget allergisk kontakteksem og halvdelen af disse tilfælde var opstået i vindmølleindustrien (15). Pontén et al. påviste i en dansk undersøgelse fra 2004 at 10,9 % af medarbejderne på en vindmøllevirksomhed, hvor man anvendte epoxy i produktionen, havde allergisk kontakteksem overfor en eller flere epoxykomponenter (9, 16, 17). Dette svarer til en hyppighed, som er 10-30 gange højere end i almenbefolkningen (14, 18)

I kompositindustrien og andre brancher, hvor man anvender epoxy, har der i mange år været arbejdet intensivt med regler og lovpligtig uddannelse, nye arbejdsprocedurer, ny teknologi, nye værnemidler og andre tekniske foranstaltninger. På trods af dette, er der stadig mange, som får epoxyeksem. Grænseværdier og overvågning af luftbårne kemiske stoffer har gennem mange år været en hjørnesten inden for det kemiske arbejdsmiljøarbejde. Dette har dog ikke været tilfældet for kemisk eksponering af huden, måske fordi det er teknisk kompliceret og ressourcekrævende at måle hudeksponering. Dette gør sig ikke mindst gældende for epoxy, som man ofte ikke kan registrere, at man får på huden.

Man har siden 1980´erne tilsat små mængder af Uvitex, Tinopal, Calcofluor og andre fluorescerende tracere til pesticider og andre kemikalier for at visualisere og kvantificere hudeksponering (19-22). Ved belysning med langbølget UV-stråling kan man visualisere udbredelsen af kontamineringen på hud, tøj og andre overflader. Med "*Video Imaging Techniques to Assess Exposure (VITAE)*", har det været muligt at analysere digitale billeder af de eksponerede hudområder og estimere koncentrationen og udbredelsen af hudeksponeringen (19, 20, 22-24). Fluorescerende tracere har også med succes været brugt til uddannelse og træning af medarbejdere, og er en integreret del af hygiejnekurser i sundhedssektoren (25, 26). Vi er ikke bekendt med at man tidligere har anvendt fluorescensteknikker til måling eller visualisering af epoxyeksponering på huden.

Projektets formål

Det oprindelige formål var at undersøge, om synliggørelse af epoxy eksponering af huden ved hjælp af fluorescens kunne nedsætte risikoen for efterfølgende eksponering, sensibilisering og eksem. Det skulle gøres ved lappetest- og spørgeskemaer udfyldt af medarbejdere før og efter brug af et fluorescens-baseret visualiseringssystem (EPOXY-VISION systemet) i et kontrolleret follow-up design. Grundet lav deltagelse, tekniske udfordringer med EPOXY-VISION systemet og Covid-19 restriktioner, blev formålene ændret undervejs.

Det overordnede formål med projektet blev derfor at undersøge forekomsten af og risikoen for eksem og epoxysensibilisering blandt medarbejdere ved to vindmøllevinge fabrikker. Derudover var det formålet, at udvikle og validere EPOXY-VISION systemet, tiltænkt som en forebyggelsesstrategi for undgå gentagen og langvarig epoxy eksponering ved at synliggøre epoxy på huden.

Delmål:

- At undersøge forekomsten af og risikoen for eksem og sensibilisering blandt epoxy-eksponerede produktionsmedarbejdere der anvender værnemidler sammenlignet med kontormedarbejdere i den danske vindmølleindustri (studie 1)

- At undersøge risikoen for eksem blandt epoxy-eksponerede produktionsmedarbejdere sammenlignet med ikke-eksponerede medarbejdere ansat på én af virksomhederne fra studie 1 (studie 2)

- At designe og validere et automatiseret fluorescens-baseret system til synliggørelse af epoxy eksponering af huden (EPOXY-VISION) (studie 3)

Projektets udførelse og metode

Studiedesigns

Studie 1: Et tværsnitsstudie af epoxy-eksponerede medarbejdere i vindmølleindustrien og en kontrol-gruppe af ikke-eksponerede

Studie 2: Et registerbaseret follow-up studie af alle medarbejdere ansat på én af fabrikkerne fra studie 1

Studie 3: Et udviklings- og valideringsstudie af et fluorescensbaseret system til synliggørelse af epoxy eksponering af huden

Studiepopulationer

Studie 1

I september 2018 blev produktionsmedarbejdere, fra afdelinger med høj risiko for hudkontakt med epoxy, på to vindmøllevinge fabrikker, inviteret til at deltage i undersøgelsen. Kontormedarbejdere fra begge fabrikker og ansatte ved Arbejdsmedicin på Aarhus Universitetshospital blev inkluderet som en kontrolgruppe.

Studie 2

Studiepopulationen bestod af 2409 ansatte hos en vindmøllevinge fabrik i perioden 2017-2021. Virksomhedsdata med eksponeringsoplysninger blev koblet med oplysninger fra nationale sundhedsregistre, med information om hospitalsdiagnoser vedrørende eksem, udførte lappetests, konsultationer hos hudlæger og receptindløsninger på binyrebarkhormoncreme. Vi ekskluderede personer, der inden start på follow-up var blevet lappetestet, havde en eksem-diagnose eller havde indløst to eller flere recepter på binyrebarkhormoncreme inden for de seneste fem år. Desuden ekskluderede vi personer, der ikke var en del af Den danske Arbejdsmiljøkohorte (DOC*X-kohorten), da vi havde data på udfaldene for personer fra denne kohorte. Vi udelukkede også medarbejdere, der blev ansat efter den 30. juni 2021, da der ikke var komplette oplysninger om udfald for disse personer. Derudover blev kvinder ekskluderet, da kun meget få af dem blev udsat for epoxy, samt medarbejdere uden gyldigt cpr-nummer.

Studie 3

Vi udviklede et fluorescens-baseret system til synliggørelse af et lysreflekterende epoxy resin system på huden, EPOXY-VISION systemet. Systemet består af to ultraviolet A (UVA) lyskilder,

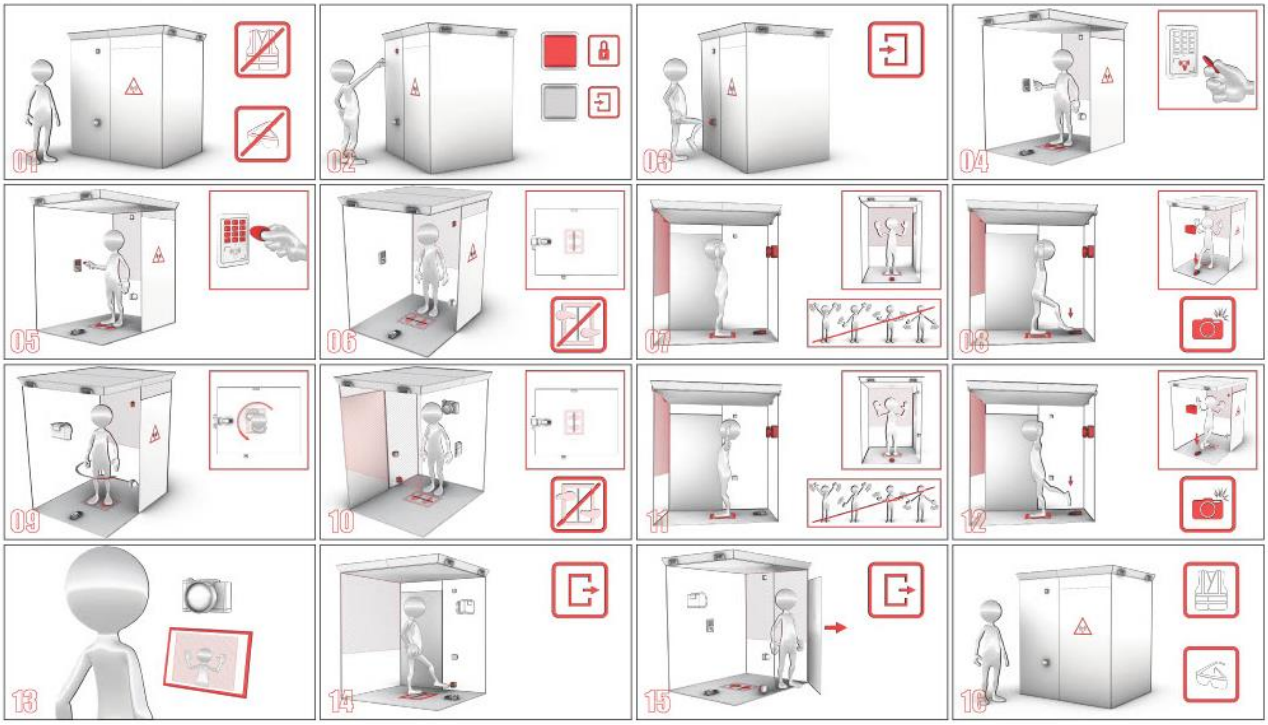
et digitalt kamera, software og en skærm installeret i en kabine (figur 1). Systemet er designet til at guide medarbejdere gennem processen ved hjælp af beskeder på skærmen og piktogrammer (figur 2) og til sidst give dem visuel feedback om, hvor de har fået epoxy på huden.

UVA-kilderne i kabinen belyser medarbejderne, når systemet aktiveres og et kamera tager billeder. Softwaren i systemet behandler billeddata og lagrer resultaterne sammen med medarbejderens ID og tidspunktet for målingen.

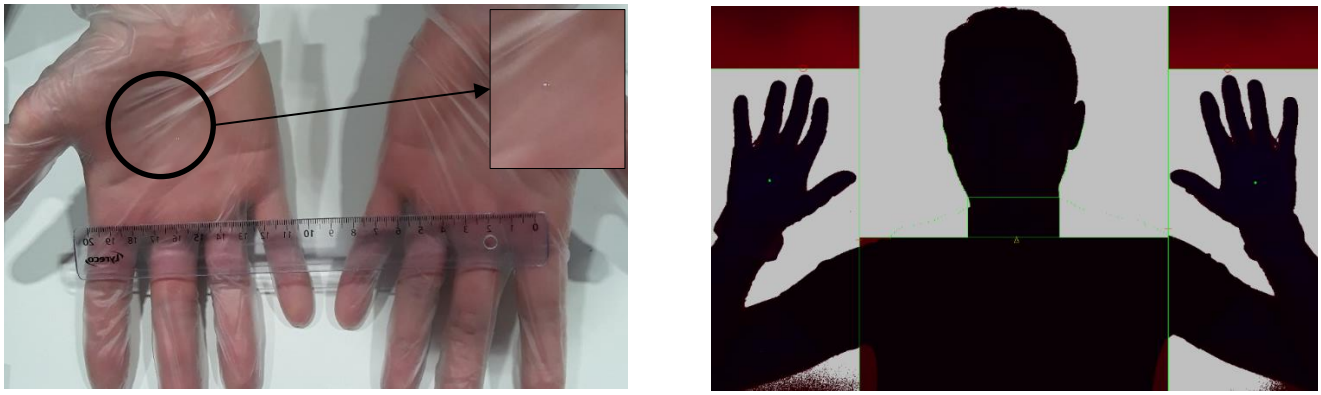
Når medarbejderne går ind i kabinen, instrueres de i at stå med front mod kameraet og hæve deres hænder, have strakte fingre og tommelfingeren tæt på ørerne. Dette gentages med ryggen mod kameraet. Konturerne af overkroppen, armene og hovedet vises på skærmen, så medarbejderen kan se om vedkommende står rigtigt.

UVA-kilderne belyser kortvarigt deltageren. Den fluorescerende tracer i epoxy resinet udstråler synligt lys, som registreres som antallet af pixels inden for det blå spektrum for hver kropsdel (hænder, arme, hoved). Antallet af pixels registreres for forsiden og bagsiden af hver kropsdel og gemmes. Fluorescensbilleder af de eksponerede områder præsenteres for medarbejderen på skærmen (figur 3).

Figur 1: EPOXY-VISION kabinen



Figur 2: Piktogrammer, der viser de forskellige trin ved brug af kabinen



Figur 3: Til venstre: Små epoxydråber (1 mm) i håndflade. Til højre: Skærmbilledet som vises for medarbejderen, hvor man kan se de små epoxy dråber i håndfladen som lyser op.

Eksponering, udfald og statistisk analyse

Studie 1

De eksponerede produktionsmedarbejdere kom hovedsageligt fra to afdelinger i produktionen, hvor man udførte spartling og laminering, og alle medarbejdere herfra blev klassificeret som epoxy-eksponerede. På virksomhed 1 var medarbejderne enten beskæftiget med spartling eller laminering, mens medarbejderne på virksomhed 2 roterede imellem opgaverne og medarbejdere fra virksomhed 2 blev klassificeret som spartlingsmedarbejdere, som ansås at være mere risikofyldt. Vi indsamlede oplysninger om ansættelsesvarighed ved hjælp af spørgeskemaer.

Udfaldet af undersøgelsen var hudsensibilisering over for epoxy (epoxysensibilisering) og forekomsten af eksem. Deltagerne blev lappetestet med en række forskellige allergener, herunder forskellige epoxykomponenter. Arbejdsprodukter, der indeholdt epoxykomponenter fra begge virksomheder, blev gennemgået, og der blev udarbejdet et tilpasset batteri af lappetests baseret på disse produkter. Lappetestningen blev udført i overensstemmelse med gældende retningslinjer for påføring og aflæsning.

Via spørgeskema indhentede vi oplysninger om udslæt på hænder, håndled og underarme, allergier, atopisk eksem (børneeksem) og epoxy-eksponering. Atopi blev defineret som selvrapporteret børneeksem i barndommen. Der blev også foretaget en klinisk undersøgelse af huden. Eksem blev defineret som enten selvrapporteret eksem inden for de seneste 12 måneder eller eksem, påvist ved den kliniske undersøgelse.

Vi undersøgte forekomsten af epoxysensibilisering og eksem blandt dem, der ikke var eksponeret for epoxy, dem der udførte laminering og dem der udførte spartlingsprocesser. Vi kiggede også på betydningen af eksponeringsvarighed ved at opdele i fire kategorier for hvor længe man havde arbejdet med epoxy (0, mindre end 1 år, 1-2 år, mere end 2 år). Ved hjælp af statistiske analyser beregnede vi odds ratio (OR) med 95% konfidensintervaller (CI) for både epoxysensibilisering og eksem sammenlignet med dem, der ikke var eksponeret for epoxy. Vi undersøgte også risikoen for eksem blandt dem, der var sensibiliseret over for epoxy, sammenlignet med dem, der ikke var sensibiliseret. Endelig estimerede vi forekomsten af sensibilisering over for forskellige epoxyprodukter og allergener, der ikke var relateret til epoxy.

Studie 2

Fra virksomheden fik vi oplysninger om medarbejdernes ansættelseshistorik, jobstatus (medarbejder eller funktionær) og afdeling (epoxyproduktion eller ingen epoxyproduktion). Medarbejdernes jobstatus og afdeling kunne ændre sig over tid, hvilket betød, at de kunne have forskellige kombinationer af jobstatus og afdeling i løbet af deres tid på fabrikken, hvilket vi tog hensyn til i analysen.

I vores analyser, der kun omfattede produktionsmedarbejdere, registrerede vi eksponeringsvarigheden som antal dage, hvor de var ansat i en eksponeret stilling. For at undersøge effekten af nylig eksponering, registrerede vi al eksponeret beskæftigelse, der fandt sted inden for de seneste 60 dage, mens eventuel eksponering uden for denne periode blev ignoreret.

Vi indhentede informationer om vital status og helbredsudfald fra CPR-registeret, Landspatientregisteret, Lægemiddelstatistikregisteret og Sygesikringsregisteret, via Den danske Arbejdsmiljøkohorte (DOC*X), som vi allerede havde tilgængelige oplysninger fra, og som inkluderede næsten hele vores studiepopulation (98.2% af de epoxyeksponerede medarbejdere).

Eksem definerede vi som enten en eksemdiagnose stillet på et hospital, have fået foretaget en lappetest eller have haft en privat konsultation hos en hudlæge angående "atopisk dermatitis, håndeksem eller psoriasis" (disse tilstande er ikke kodet separat). Oplysninger blev hentet fra Landspatientregisteret og Sygesikringsregisteret.

Lokalbehandling med binyrebarkhormoncreme er den foretrukne behandling mod eksem. For at fange arbejdere, der udviklede eksem, men som endnu ikke havde fået en diagnose eller lappetest, inkluderede vi et sekundært udfald, som var indløsning af en eller flere recepter på binyrebarkhormoncreme. Oplysninger blev indhentet fra Lægemiddelreceptregisteret.

Oplysninger om uddannelsesniveau og specifik beskæftigelse, alder og køn blev også registreret. Vi fulgte hver arbejder fra deres ansættelsesstart i 2017 til enten de udviklede eksem, døde, flyttede eller slutdato for studiet i 2021. Vi beregnede incidence rate ratioer med Poisson regression justeret for alder med de ikke-eksponerede medarbejdere som referencegruppe. Godkendelse fra etiske komitéer var ikke nødvendigt, da der er tale om et registerstudie.

Studie 3

Vi undersøgte validiteten af EPOXY-VISION systemet med et kommercielt epoxyprodukt, der indeholder et fluorescerende sporstof. Deltagerne bar handsker for at undgå at få epoxy på huden, samt sorte t-shirts for at undgå fluorescens fra andre kilder end epoxyen. Epoxydråber med diameter 1 mm blev placeret forskellige steder på deltagernes hænder og lysniveauet fra den fluorescerende epoxy blev kvantificeret ved hjælp af kameraer og efterfølgende software behandling af billederne. Vi udførte flere gentagne målinger. Vi undersøgte også mulige kilder til forstyrrende lys ved at teste forskellige genstande efter UVA-stråling. Vi beregnede systemets sensitivitet og estimerede den relative risiko for ikke at finde en epoxydråbe, samt hvilken betydning afstanden til kameraet havde for systemets evne til at finde dråberne.

Resultater: Om projektets formål er blevet opnået

Studie 1

I alt deltog 180 produktionsmedarbejdere, 153 (43,3%) fra fabrik 1 og 27 (28,7%) fra fabrik 2. I kontrolgruppen (kontormedarbejdere samt ansatte ved Arbejdsmedicin, Aarhus Universitets Hospital) deltog i alt 41 (2,8%).

Vi fandt at 16 (8,9%) epoxy-eksponerede produktionsmedarbejdere var epoxysensibiliserede, mod ingen af de ikke-eksponerede kontorarbejdere (OR 8,3; 95 % CI: 0,5-141,6) (tabel 4). Epoxysensibilisering forekom hyppigere blandt medarbejdere, der udførte spartlingsprocedurer; 12 ud af 16 sensibiliserede arbejdede i dette område. Epoxysensibilisering forekom oftest efter kortvarig eksponering hvor 10 ud af 16 blev sensibiliseret inden for det første år. Blandt ikke-atopiske medarbejdere fandt vi en øget risiko for eksem blandt eksponerede medarbejdere sammenlignet med ikke-eksponerede medarbejdere (OR 2,3; 95 % CI: 0,6-9,1), mens det modsatte blev observeret for atopiske medarbejdere (tabel 5). Vi fandt en øget risiko for at have eksem hvis man var epoxysensibiliseret (OR 4,5; 95% CI:1.6-12.7).

Studie 2

Blandt 2409 medarbejdere observerede vi 41 tilfælde af eksem. Medarbejdere der arbejdede med epoxy, havde en højere risiko for eksem sammenlignet med dem, der ikke var udsat (IRR 2,4; 95% CI: 1,2-5,0). Risikoen var højst det første år de arbejdede (IRR 3,7; 95% CI: 1,6-8,6) og faldt med længere varighed af eksponering. Der var også en øget risiko for eksem hos medarbejdere, der havde været udsat for epoxy inden for de seneste 0-60 dage (IRR 2,9; 95% CI: 1,5-5,9).

Studie 3

Vi udførte 800 målinger for at teste systemets evne til at opdage epoxydråber forskellige steder på hænderne. Sensitiviteten af systemet varierede afhængigt af placeringen. På håndfladen blev dråberne generelt opdaget med høj sensitivitet (89% - 100%), mens sensitiviteten på håndryggen varierede mellem 59% og 100%. Dråber placeret mellem fingrene (testet mellem 3. og 4. finger) havde meget lav sensitivitet (2% - 55%). Når hænderne var placeret tæt på kameraet, var sensitiviteten for både håndflade og håndryg mellem 95% og 100%. Vi fandt ikke fluorescence af sikkerhedsbriller, smykker og ure, men af bomuldshandsker, øreprupper og sikkerhedsjakker.

Konklusioner

Selv med omfattende beskyttelsesforanstaltninger er der stadig en høj forekomst af epoxysensibilisering og eksem blandt medarbejdere, der arbejder med epoxy i vindmølleindustrien. Undersøgelsen viser, at sensibilisering og eksem opstår tidligt i ansættelsesforløbet. Dette understreger behovet for intensiveret uddannelse af nyansatte medarbejdere, for at etablere en sikker arbejdsadfærd i begyndelsen af deres karriere. Interessant nok viser undersøgelsen også, at selvom risikoen for at udvikle eksem var seks gange højere hos dem der var sensibiliserede, havde 60% af de sensibiliserede ikke eksem. Denne høje andel af sensibiliserede medarbejdere uden symptomer understreger behovet for kontinuerligt og vedvarende fokus på sikkerhedsprocedurer for at minimere risikoen for senere at udvikle eksem. Vi har udviklet et fluorescens-baseret system til at opdage eksponering på håndflader og håndrygge med høj sensitivitet. Det giver øjeblikkelig feedback og information om eksponering til medarbejderne og kan indgå i en fremtidig strategi til forebyggelse af eksponering blandt udsatte medarbejdere. Selvom systemet har brug for yderligere forbedringer og validering, finder vi, at det tilbyder et værdifuldt redskab til at identificere eksponering under arbejde. Systemet forventes også at kunne anvendes i andre brancher med risiko for eksponering for andre kemikalier på huden.

Perspektiver: Hvordan resultaterne på kort og lang sigt kan bidrage til at forbedre arbejdsmiljøet

Vindenergi er en bæredygtig energikilde i hastig udvikling. EU forventer at 50% af elektrisk strøm skal komme fra vind i 2050, og et stigende antal medarbejdere vil blive ansat i vindmølle

produktion. Vores undersøgelser bekræfter at eksponering for epoxy i vindmølleindustrien fortsat har sundhedsmæssige konsekvenser. At finde alternative produkter, der er mindre allergifremkaldende, samt innovative strategier til at forhindre eksponering, er vigtigt for at opretholde et sikkert arbejdsmiljø i denne voksende industri.

Vi planlægger at videreudvikle EPOXY-VISION-systemet, og der er etableret samarbejde med vindmøllefabrikker i Danmark, Spanien og Portugal med henblik på at undersøge systemets evne til at nedsætte epoxyeksponering af huden, sensibilisering og eksem. Vi håber inden for en kort årrække at kunne implementere systemet blandt produktionsmedarbejdere og forebygge de sundhedsproblemer der er forbundet med epoxyarbejde.

En fortegnelse over publikationer og produkter fra projektet

Skriftlig videnskabelig formidling

Christiansen AG, Carstensen O, Sommerlund M, Clausen PA, Bønløkke JH, Schlünssen V, Isaksson M, Schmidt SAJ, Kolstad HA. Prevalence of skin sensitization and dermatitis among epoxy-exposed workers in the wind turbine industry. Br J Dermatol. 2022 Dec;187(6):988-996. doi: 10.1111/bjd.21830. Epub 2022 Sep 16. PMID: 35972390; PMCID: PMC10087335.

Christiansen AG, Kinnerup MB, Carstensen O, Sommerlund M, Clausen PA, Bønløkke JH, Schlünssen V, Isaksson M, Schmidt SAJ, Kolstad HA. Occupational exposure to epoxy components and risk of dermatitis: A registry-based follow-up study of the wind turbine industry. Contact Dermatitis. 2024 Jan;90(1):32-40. doi: 10.1111/cod.14431. Epub 2023 Oct 5. PMID: 37795841.

Christiansen AG, Carstensen O, Sommerlund M, Clausen PA, Bønløkke JH, Schlünssen V, Isaksson M, Schmidt SAJ, Majland A, Kolstad HA. An automatic computerized fluorescence-based system for measuring epoxy exposure of the skin during regular work: EPOXY-VISION (manuscript).

Øvrig skriftlig videnskabelig formidling

Alexandra Golabek Christiansen, “Risk and prevention of dermatitis and skin sensitization following exposure to epoxy components”, Ph.d.-afhandling, Health, Aarhus Universitet, maj 2023.

Mundtlig videnskabelig formidling

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per Axel Clausen, Jakob Bønløkke, Vivi Schlünssen, Charlotte Amalie Ihlo, Marléne Isaksson, Pia Christoffersen, Christian Libak, Marcus Illanes, Henrik Albert Kolstad, “Prevention of dermatitis in epoxy exposed lamination workers producing wind turbine blades: An intervention study using fluorescence visualization”, 9th International Conference on the Science of Exposure Assessment, Manchester UK, September 2018. The poster was awarded a price for the best poster.

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per Axel Clausen, Jakob Bønløkke, Vivi Schlünssen, Charlotte Amalie Ihlo, Marléne Isaksson, Pia Christoffersen, Christian Libak, Marcus Illanes, Henrik Albert Kolstad, “Prevention of dermatitis in epoxy exposed

lamination workers producing wind turbine blades: An intervention study using fluorescence visualization”, 2nd Annual Research Meeting, Department of Clinical Medicine, poster præsentation, november 2018.

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per Axel Clausen, Jakob Bønløkke, Vivi Schlünssen, Charlotte Amalie Ihlo, Marléne Isaksson, Pia Christoffersen, Christian Libak, Marcus Illanes, Henrik Albert Kolstad, "Prevention of dermatitis in epoxy exposed lamination workers producing wind turbine blades: An intervention study using fluorescence visualization", PhD Day, poster præsentation, januar 2019.

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per Axel Clausen, Jakob Bønløkke, Vivi Schlünssen, Charlotte Amalie Ihlo, Marléne Isaksson, Pia Christoffersen, Christian Libak, Marcus Illanes, Henrik Albert Kolstad, "Risk and prevention of sensitization and contact dermatitis among workers handling epoxy resins", 27th International Symposioum on Epidemiology in Occupational Health, EPICOH, poster præsentation, New Zealand, april 2019.

Alexandra Golabek Christiansen, Ole Carstensen[2], Mette Sommerlund, Per Axel Clausen, Jakob Bønløkke, Vivi Schlünssen, Marléne Isaksson, Henrik Albert Kolstad, "Risk and prevention of dermatitis among epoxy exposed workers: A study of the wind turbine industry", 3rd Annual Research Meeting, Department of Clinical Medicine, poster præsentation, november 2019.

Alexandra Golabek Christiansen, ”Epoxy Vision projektet, synligt og sikkert arbejde med epoxy: Forebyggelse ved visualisering”, Dansk Dermatologisk Selskabs årskonference, oplægsholder november 2019.

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per Axel Clausen, Jakob Bønløkke, Vivi Schlünssen, Marléne Isaksson, Henrik Albert Kolstad, "Risk and prevention of dermatitis among epoxy exposed workers", online poster præsentation, PhD Day, januar 2021.

Alexandra Golabek Christiansen, Ole Carstensen, Mette Sommerlund, Per A. Clausen, Jakob Bønløkke, Vivi Schlünssen, Marléne Isaksson, Henrik A. Kolstad, "Risk of dermatitis and epoxy sensitization among epoxy exposed workers in the wind turbine industry", online mundtlig præsentation, 28th International Symposium on Epidemiology in Occupational Health, EPICOH, oktober 2021.

Alexandra Golabek Christiansen, "Epoxy-vision projektet", Dansk Selskab for Arbejds- og Miljømedicin, Årskonference, mundtligt oplæg, marts 2022.

Alexandra Golabek Christiansen, "Sensitization and dermatitis among epoxy exposed lamination workers producing wind turbine blades", PhD Day, mundtligt oplæg, juni 2022.

Alexandra Golabek Christiansen, "Epoxy Vision", Ramazzini seminar, mundtligt oplæg, oktober 2022.

Alexandra Golabek Christiansen, "Occupational exposure to epoxy and risk of dermatitis: A register-based follow-up study of the wind turbine industry", 29th International Symposium on Epidemiology in Occupational Health EPICOH, online mundtligt oplæg, Marts 2023.

Alexandra Golabek Christiansen, "Risk and prevention of dermatitis and skin sensitization following exposure to epoxy components", Ph.d- forsvar, august 2023.

Mundtlig populær formidling

Alexandra Golabek Christiansen,"Epoxy Vision projektet, synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering", oplægsholder, EcoOnline sommerseminar, VIA University College, Aarhus, august 2018.

Alexandra Golabek Christiansen,"Epoxy Vision projektet, synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering", oplægsholder, Arbejdsmiljørådet, Arbejdstilsynet, København, maj 2019.

Alexandra Golabek Christiansen,"Epoxykonference Svendborg", oplægsholder, Epoxykonference, Industriens Uddannelser, Svendborg, juni 2019.

Alexandra Golabek Christiansen,"Arbejdsbetingede hudlidelser", oplægsholder, Arbejdstilsynet, Tilsynscenter Nord, Hadsten, marts 2022.

Alexandra Golabek Christiansen,"Epoxy Vision projektet", præsentation af resultater for ledelsen og medarbejdere på Siemens Gamesa Renewable Energy og Vestas Wind Systems A/S, oktober/november 2021 og februar/marts 2022.

Nyheder, hjemmesider, tidsskrifter

Dagbladet Ringkøbing-Skjern, "Vestas med i stort Epoxy-projekt", maj 2018.

Vindmølle-arbejdere skal testes for usynlig fare | dagbladet-holstebro-struer.dk, april 2018.

Forskere tester: Selvlysende epoxy skal forhindre syge medarbejdere | Fagbladet 3F, april 2018.

Magasinet Arbejdsmiljø, "Selvlysende epoxy skal forhindre syge medarbejdere", april 2018.

Selvlysende epoxy skal forhindre syge medarbejdere (metal-supply.dk), april 2018.

Aarhus Stiftstidende, Erhverv+ Østjylland, " Ny dansk kabine skal forebygge hændelser med epoxy", november 2019.

Magasinet Arbejdsmiljø, "Forsker på job", marts 2021.

Bilag 1: Skriftlig videnskabelig formidling med peer review

BJD
British Journal of Dermatology

Prevalence of skin sensitization and dermatitis among epoxy-exposed workers in the wind turbine industry

Alexandra G. Christiansen,[1] Ole Carstensen,[2] Mette Sommerlund,[3] Per A. Clausen,[4] Jakob H. Bønløkke,[5] Vivi Schlünssen,[4,6] Marléne Isaksson,[7] Sigrun A. J. Schmidt[3,8] and Henrik A. Kolstad[1,9]

[1]Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark
[2]Department of Occupational Medicine, The Regional Hospital Goedstrup, University Research Clinic, Herning, Denmark
[3]Department of Dermatology, Aarhus University Hospital, Aarhus, Denmark
[4]National Research Centre for the Working Environment, Copenhagen, Denmark
[5]Department of Occupational and Environmental Medicine, Danish Ramazzini Centre, Aalborg University Hospital, Aalborg, Denmark
[6]Department of Public Health, Danish Ramazzini Centre, Aarhus University, Aarhus, Denmark
[7]Department of Occupational and Environmental Dermatology, Lund University, Skane University Hospital Malmö, Malmö, Sweden
[8]Department of Clinical Epidemiology, Aarhus University Hospital, Aarhus, Denmark
[9]Institute of Clinical Medicine, Aarhus University, Aarhus, Denmark

Correspondence
Alexandra Golabek Christiansen.
Email: alexpe@rm.dk

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Summary

Background A high prevalence of skin sensitization and dermatitis has been reported among workers exposed to epoxy components.
Objectives To estimate the risk of skin sensitization and dermatitis among workers exposed to epoxy components during production of wind turbine blades while using comprehensive safety measures.
Methods A cross-sectional study of 180 highly epoxy-exposed production workers and 41 nonexposed office workers was conducted at two wind turbine blade factories in Denmark. Participants underwent a skin examination, were tested with a tailored patch test panel including epoxy-containing products used at the factories, and answered a questionnaire.
Results Sixteen production workers (8·9%) were sensitized to an epoxy component compared with none of the office workers. Skin sensitization was more frequent within the first year of exposed employment. Strong selection bias by atopic status was indicated. Among nonatopic workers, the prevalence of dermatitis was higher among production workers (16·4%) than among office workers [6·5%, odds ratio (OR) 2·3, 95% confidence interval (CI) 0·6–9·1] and higher among the sensitized workers (43·8%) than the nonsensitized workers (14·6%, OR 4·5, 95% CI 1·6–12·7). Resins based on diglycidyl ether of bisphenol A and F were the most frequent sensitizers. One of the four workers sensitized to epoxy components used at the factories did not react to the epoxy resin of the TRUE test® panel.
Conclusions Despite comprehensive skin protection, sensitization and dermatitis are prevalent among highly epoxy-exposed workers in the wind turbine industry in Denmark. Our findings document the need for intensified preventive efforts and emphasize the importance of tailored patch testing.

What is already known about this topic?

- Epoxy components are well-known sensitizers of the skin.
- A high prevalence of skin sensitization and dermatitis has been reported among workers exposed to epoxy components.
- Comprehensive protective equipment is recommended when working with epoxy components.

What does this study add?

- Despite comprehensive skin protection, skin sensitization and dermatitis are prevalent among epoxy-exposed workers.
- We found that 40% of workers sensitized to epoxy products had dermatitis.
- Only 75% of the sensitized workers were detected by the epoxy resin of the TRUE test®, which emphasizes the importance of tailored testing.

Epoxy resin systems are materials with high mechanical, chemical and thermal resistance. They are widely used as components of protective surfaces, adhesives and paints and in the manufacturing of composites in the plastics industry. Epoxy resin systems consist of resins, hardeners, reactive diluents and additives (hereafter named epoxy components).[1,2] All components can cause sensitization of the skin, resins being the most frequent sensitizers and one of the leading causes of occupational allergic contact dermatitis.[3,4] In Denmark in 2010, epoxy resins were found to be the second-most common cause of occupational allergic contact dermatitis.[5] A 2004 study from the wind turbine industry showed that 10·5% of all participating workers were sensitized to epoxy resins, 20–50 times the prevalence in the general population.[6–10]

Approximately 75% of epoxy resins are derived from bisphenol A and epichlorohydrin, also known as diglycidyl ether of bisphenol A (DGEBA).[11] DGEBA-resins (DGEBA-R) are strong sensitizers of the skin, owing to DGEBA. The content of DGEBA in epoxy resins varies and the DGEBA polymers are described by different Chemical Abstracts Service (CAS) numbers, e.g. 25068-38-6 and 25085-99-8.[12] Epoxy resins are often also based on diglycidyl ether of bisphenol F (DGEBF). Concomitant reactions to DGEBF resin (DGEBF-R, CAS numbers 28064-14-4 and 9003-36-5) and DGEBA-R are well known, owing to cross-reactivity.[13]

In many industries, good alternatives to epoxy resin systems are lacking, and the prospect of finding a suitable substitute in the near future is not very realistic. In fact, the use of epoxy resin systems is expanding.[14,15] An increase in sensitization to epoxy resins has been observed in the construction industry in Germany during recent years.[15] Therefore, for several years, considerable attention has been devoted to regulation, education, substitution, new procedures and protective equipment. However, little is known about the risk of skin sensitization and dermatitis when using comprehensive protective measures.

We conducted a cross-sectional study in the wind turbine industry which examined the prevalence of skin sensitization and dermatitis among highly epoxy-exposed production workers who used comprehensive safety measures compared with nonexposed office workers.

Materials and methods

Study population

In September 2018, we invited epoxy-exposed production workers from two factories in Denmark (Factory 1 and Factory 2) that produced wind turbine blades. The workers were all involved in manual lamination or filling procedures with expected high risk of skin contamination. During meetings at the factories, all production workers were informed about the study by A.G.C. and were personally handed information leaflets. Office workers at the two factories and at the Department of Occupational Medicine, Aarhus University Hospital were invited via their work email address to participate as a nonexposed control group. Office workers at Factory 1 worked close to the production site and had prior knowledge of the study, whereas office workers from Factory 2 worked far away from the production site with no prior knowledge of the study.

In October 2020, participating production workers at Factory 1 were invited by private email for a follow-up. As a result of downsizing, only a few production workers at Factory 2 remained employed and they were not invited for follow-up.

The study was registered at the repository of the Central Denmark Region (j.nr 2012-58-006).

Work procedures and personal protective equipment

During the lamination procedure, large casting defects of the wind turbine blades are removed with an angle grinder. The defects are repaired by hand lamination. Clear liquid epoxy is applied on fiberglass mats using a handheld roller. Each worker uses a few kilograms of epoxy resins daily. During the filling procedure, small casting defects are filled with a viscous epoxy filler and smoothed with a scraper. This procedure is physically demanding and entails close contact with the resins and carries a high risk of spilling. Each worker uses about 15 kg of epoxy filler daily. During both procedures, workers wear a protective suit with a hood, a face shield, protective glasses, safety shoes, and often an apron, protective arm sleeves and chemically resistant disposable nitrile-rubber gloves. Glove

thickness varies from 0·12 mm to 4·2 mm depending on the processes involved. All gloves are tested at a laboratory for permeability against the relevant products. Thin gloves were tested to provide protection for 0·5–8 h and were never used for more than 0·5 h. Thick gloves were tested to provide protection for 8 h and were changed every second hour.

In Factory 1, workers did either lamination or filling, whereas in Factory 2, workers rotated between the two procedures. In the analyses, we classified the rotating workers of Factory 2 together with the filling workers of Factory 1 because of the higher exposure load of the filling process.

Questionnaire

The questionnaire was a shortened version of the Nordic Occupational Skin Questionnaire[16–18] containing questions on former and current rashes (on hands, wrists and forearms), allergies, history of atopic dermatitis in childhood, asthma, respiratory symptoms and rhinitis. Questions about exposure to epoxy resins were added. We defined atopy by the presence of atopic dermatitis during childhood.

Patch testing and clinical examination

Production workers were patch tested from December 2018 to March 2019 and September 2019 to November 2019 at Factory 1 and 2, respectively. The production workers of Factory 1 were retested in May 2021 to identify new cases of sensitization and to assess the persistence of sensitization detected at baseline.

Office workers were tested only once from November 2019 to September 2020. Production workers and office workers at Factory 1 and Factory 2 were tested with the nine and the 13 epoxy products that were handled at each of the two factories. Six office workers from the Department of Occupational Medicine were tested as participants from Factory 1 and four were tested as participants from Factory 2.

Before the patch tests were prepared, we performed a thorough review of all products included. Thus, we reviewed the sensitizing potential of all components in a product and set the patch test concentration based on the component with the strongest sensitization potential. We took into account which patch test concentration the various chemicals have in commercial patch test series and used a security factor of two for products containing DGEBA and DGEBF. For example, if epoxy resin bisphenol A was present at or above 50% and epoxy resin, bisphenol F up to 10–25%, the patch test concentration of that work product was set to be 0·5%, as epoxy resin bisphenol A is tested at 1·0% in baseline panels and epoxy resin bisphenol F is tested at 0·25% in epoxy panels. The test materials were diluted in petrolatum. All test preparations were prepared at the Department of Occupational and Environmental Dermatology, Malmö, Sweden.

In order to identify specific allergic reactions, participants (production workers and office workers) from Factory 1 with a positive patch test for epoxy products were additionally tested with bisphenol A and a series of 15 specific epoxy allergens (Chemotechnique Diagnostics, Vellinge, Sweden) (Table S1; see Supporting Information). Participation during this second step was low. At Factory 2, we therefore tested all participants with bisphenol A and six selected allergens from the epoxy series at the same time as the work products. We restricted testing to these six allergens that were declared for the products used by the workers to keep the potential risk of sensitization low.

Participants were also tested using the Thin-Layer Rapid Use Epicutaneous (TRUE) test® panel 1–3, containing DGEBA-R and 34 other allergens (SmartPractice, Hillerød, Denmark) supplemented with the following five additional nonepoxy allergens frequently occurring in work materials: benzisothiazolinone, methylisothiazolinone, formaldehyde, iodopropyl butylcarbamate (SmartPractice, Calgary, Canada) and 2-n-octyl-4-isothiazolin-3-one (Chemotechnique Diagnostics, Vellinge, Sweden) (Table S2; see Supporting Information).

Finn Chambers (Ø 8 mm) (SmartPractice) on Scanpor® tape (Norgesplaster A/S, Vennesla, Norway) were used for the test substances. For allergens in petrolatum, 20 mg was applied, whereas the amount applied for aqueous solutions was 15 μL on a paper filter.[19]

Patch testing was performed on site during work hours. Test materials were placed on the upper back and occluded for 48 h. If the back was not suitable, outer upper arms or thighs were used as an alternative (15 participants) as recommend by the European Society of Contact Dermatitis.[19] Two readings, preferably on day (D)4 and D6, were performed by an experienced biomedical laboratory technician. Readings were graded according to criteria established by the European Society of Contact Dermatitis.[19] Readings coded as +, ++ or +++ were all considered as positive in dichotomized analyses. Photodocumentation of the participant's back was made before application of the tests and at the readings. In case of patch test reactions later than D6, the participants were instructed to report and photodocument the reaction.

Clinical skin examination of the hands, upper extremities and truncus for signs of dermatitis (dryness, chapping, redness, infiltration, papules, vesicles and hyperkeratosis) was performed by the A.G.C. prior to patch test application. Dermatitis was defined as either self-reported dermatitis within 12 months based on the questionnaire or dermatitis present at the clinical examination.

We informed only the participants and not the employers about findings for the individual participants. We are aware that many of the sensitized individuals informed their employers and were transferred to nonexposed jobs within the factories, but we did not systematically collect this information.

Ethical considerations

Active sensitization is a potential adverse event when patch testing. Existing literature shows that the risk is minimal, when testing with commercially available allergens.[20–23] In

Denmark, more than 20 000 persons are tested annually with DGEBA-R included in a baseline series, which is an approved medical product. When testing with work products the risk is higher and a thorough review of the work products was performed. Patch test concentration was determined on the basis of concentrations used in commercial patch tests or as recommended in previous literature.[24] Furthermore, a security factor of two was used in products containing DGEBA or DGEBF in order to minimize the risk of active sensitization as described above.

The Regional Ethical Committee has approved the study (1-10-72-52-18). All individuals were informed about the risk and gave informed consent before inclusion.

Statistical analyses

We computed prevalence of sensitization and dermatitis at baseline and follow-up and estimated odds ratios (ORs) with 95% confidence intervals (CIs) for both endpoints using penalized likelihood analysis.[25] Stratified analyses were performed to evaluate the possible modifying effect of atopy. Sex was unequally distributed across exposure status, and we performed sensitivity analyses of men only. Participation rate was very low among office workers from Factory 2, and we also performed sensitivity analyses excluding all participants from Factory 2. Statistical analyses were performed using Stata version 17.0 (StataCorp, College Station, TX, USA).

Results

In total, 447 exposed production workers were invited to participate in the study (Table S3; see Supporting Information). In total, 180 (40·3%) consented and were patch tested: 153 (43·3%) from Factory 1 who performed filling or lamination operations and 27 (28·7%) from Factory 2 who performed mixed filling and lamination operations. Of the 1481 invited nonexposed office workers, 41 (2·8%) consented and were patch tested: 16 (21·3%) from Factory 1, 15 (1·1%) from Factory 2 and 10 (38·5%) from the Department of Occupational Medicine. Twenty-one (13·7%) patch tested production workers from Factory 1 participated at follow-up.

Twenty participants were absent at one reading. Photodocumentation of the reaction on the missing day was provided by nine participants (two were epoxy sensitized); the remaining participants had only one reading at either D4 (seven, with one epoxy sensitized) or D6 (four, with one epoxy sensitized). Ten participants were absent at both readings. Of these, four provided photographs of 2 days, either D4 and D6 or D3 and D5, and six provided a photograph on D4 (one epoxy sensitized).

Production workers were considerably younger, less often women, reported atopic dermatitis less frequently and smoking more often, had been employed for a shorter period and were less often sensitized to nonepoxy allergens of the TRUE test® than office workers (Table 1).

Table 1 Characteristics of participants by exposure status to epoxy components in the wind turbine industry

Characteristics	Exposure status	
	Exposed production workers (n = 180)	Nonexposed office workers (n = 41)
Age, years		
Mean (range)	34·5 (19–65)	46·8 (29–63)
Age group, n (%)		
< 30 years	70 (38·9)	1 (2·4)
30–39 years	64 (35·6)	9 (22·0)
≥ 40 years	46 (25·6)	31 (75·6)
Sex, n (%)		
Male	178 (98·9)	19 (46·3)
Female	2 (1·1)	22 (53·7)
Atopic dermatitis (self-reported), n (%)		
Yes	17 (9·4)	7 (17·1)
No	159 (88·3)	31 (75·6)
Missing	4 (2·2)	3 (7·3)
Allergic rhinitis (self-reported), n (%)		
Yes	39 (21·7)	7 (17·1)
No	137 (76·1)	31 (75·6)
Missing	4 (2·2)	3 (7·3)
Asthma (self-reported), n (%)		
Yes	25 (13·9)	6 (14·6)
No	153 (85·0)	32 (78·1)
Missing	2 (1·1)	3 (7·3)
Duration of employment, n (%)		
< 1 year	62 (34·4)	6 (14·6)
1–4 years	57 (31·7)	9 (22·0)
≥ 5 years	49 (27·2)	23 (56·1)
Missing	12 (6·7)	3 (7·3)
Smoking, n (%)		
Current	88 (48·9)	5 (12·2)
Former	44 (24·4)	11 (26·8)
Never	48 (26·7)	22 (53·7)
Missing	0 (0·0)	3 (7·3)
Sensitization to a TRUE Test® allergen other than epoxy resin, n (%)	15 (8·3)	9 (22·0)

In total, 16 (8·9%) of the production workers were sensitized to an epoxy component compared with none of the office workers (OR 8·3, 95% CI 0·5–141·6), with higher estimates among workers who performed filling operations (OR 14·9, 95% CI 0·9–258·8) (Table 2). The prevalence of sensitization to epoxy components decreased with increasing duration of exposed employment from 16·1% among those employed for 1 year or less to 4·1% among those employed for 2 years or more. Dermatitis affected 29 (16·1%) of the production workers and eight (20%) of the office workers (OR 0·8, 95% CI 0·3–1·8). Results that were restricted to men (Table S4; see Supporting Information) and Factory 1 (Table S5; see Supporting Information) were similar.

Table 2 Exposure to epoxy components and odds ratios (ORs) for epoxy sensitization and dermatitis in the wind turbine industry[a]

		Epoxy sensitization		Dermatitis	
Procedures and duration of epoxy exposure	Total, n	n (%)	OR (95% CI)	n (%)	OR (95% CI)
Nonexposed office workers	41	0 (0)	1 (ref.)	8 (19·5)	1 (ref.)
Exposed production workers	180	16 (8·9)	8·3 (0·5–141·6)	29 (16·1)	0·8 (0·3–1·8)
Lamination	99	4 (4·0)	3·9 (0·2–74·3)	8 (8·1)	0·4 (0·1–1·0)
Filling	81	12 (14·8)	14·9 (0·9–258·8)	21 (25·9)	1·4 (0·6–3·4)
Duration of exposed employment					
None	41	0 (0)	1 (ref.)	8 (19·5)	1 (ref.)
< 1 year	62	10 (16·1)	16·6 (0·9–291·6)	16 (25·8)	1·4 (0·5–3·6)
1–2 years	57	3 (5·3)	5·3 (0·3–106·1)	5 (8·8)	0·4 (0·1–1·3)
> 2 years	49	2 (4·1)	4·4 (0·2–93·6)	6 (12·2)	0·6 (0·2–1·8)
Missing	12	1 (8·3)	–	2 (16·7)	–

CI, confidence interval; ref., reference. [a]A total of 221 participants.

Table 3 shows results stratified by atopic status and indicates no effect modification for sensitization. On the other hand, there were indications for such an effect for dermatitis because, among nonatopic workers we found an increased prevalence of dermatitis among production workers compared with office workers (OR 2·3, 95% CI 0·6–9·1), while an inverse association was seen for atopic workers (OR 0·1, 95% CI 0·0–0·5). Sensitivity analyses including only men (Table S6; see Supporting Information) and only workers from Factory 1 (Table S7; see Supporting Information) showed similar results.

Among all participants, 43·8% of sensitized workers had dermatitis and 14·6% of workers who were nonsensitized to epoxy had dermatitis (Table 4). This yields a fourfold increased odds of dermatitis (OR 4·5, 95% CI 1·6–12·7) among workers sensitized to epoxy components.

All 16 sensitized participants tested positive to work products containing both DGEBA and DGEBF, and 12 tested positive to DGEBA-R from the TRUE test® panel (Table 5). All 27 participants from Factory 2 and four of 13 eligible participants from Factory 1 were additionally tested with DGEBF-R from the Chemotechnique epoxy series; five participants had a concomitant reaction to DGEBF-R and two had a solitary reaction to DGEBF-R. Thus, 14 of the 16 sensitized participants were detected by the combination of the commercial tests. Furthermore, three participants had reactions to 2-phenyl glycidyl ether, 1,6-hexanediol diglycidyl ether and 1,4-butanediol diglycidyl ether. Only two participants were sensitized to a hardener product; supplemental testing did not identify the exact allergen of the product. Main constituents and CAS numbers of products causing positive patch test results are shown in Table S8 (see Supporting Information). The frequency of sensitization to additional nonepoxy allergens (benzisothiazolinone, methylisothiazolinone, formaldehyde, iodopropyl butylcarbamate and 2-n-octyl-4-isothiazolin-3-one) was low among production workers and office workers (Table S2).

Among the 21 production workers who participated in the follow-up, no new skin sensitizations to epoxy components were found, despite continued exposure for all but two participants. Two participants (10%) developed dermatitis during

Table 4 Epoxy sensitization and odds ratio (OR) for dermatitis among workers in the wind turbine industry

	Total, n	Dermatitis, n (%)	OR (95% confidence interval)
No epoxy sensitization	205	30 (14·6)	Reference
Epoxy sensitization	16	7 (43·8)	4·5 (1·6–12·7)

Table 3 Exposure to epoxy components and odds ratios (ORs) for dermatitis and epoxy sensitization by atopic status in the wind turbine industry[a]

		Epoxy sensitization		Dermatitis	
Atopic status and exposure to epoxy components	Total, n	n %	OR (95% CI)	n %	OR (95% CI)
Nonatopic (n = 190)					
Nonexposed office workers	31	0 (0)	1 (ref.)	2 (6·5)	1 (ref.)
Exposed production workers	159	13 (8·2)	5·8 (0·3–100·2)	26 (16·4)	2·3 (0·6–9·1)
Atopic (n = 24)					
Nonexposed office workers	7	0 (0)	1 (ref.)	6 (85·7)	1 (ref.)
Exposed production workers	17	3 (17·7)	3·6 (0·2–79·7)	3 (17·7)	0·1 (0·0–0·5)

CI, confidence interval; ref., reference. [a]Information on atopic dermatitis was missing for seven participants.

Table 5 Positive patch test results by product and allergen test material in the wind turbine industry at day (D)4 and D6[a]

Test material	Case number 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Epoxy resin TRUE test®	−/−	+/+	+/+	+/+	++/++	+/+	+/+	+/÷	+/+	+/−	−/−	+/+	+/+	−/−	+/−	−/−
Product[b]																
Resin no. 1	+/+	?/+	+/+	+/+	+++/++	+/+	+/+	+/÷	+/+	+/+	+/+	++/+	+/+	NT	NT	NT
Resin no. 2	+/+	+/+	+/+	+/+	+++/++	+/+	++/++	+/÷	+/+	++/++	+/+	+/+	+/+	NT	NT	NT
Resin no. 3	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	+/+	+/+	−/+
Resin no. 4	+/+	+/+	+/+	+/+	+++/++	+/+	+/+	+/÷	+/++	+/+	+/+	+/+	+/+	+/+	+/+	−/+
Resin no. 5	+/+	?/+	+/+	+/+	+++/++	+/+	++/+	+/÷	++/++	+/++	+/+	++/+	++/+	NT	NT	NT
Resin no. 6	+/+	+/+	+/+	+/+	+++/++	−/+	+/++	+/÷	+/+	++/++	+/+	+/+	+/+	NT	NT	NT
Resin no. 7	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	+/+	+/−	−/−
Hardener no. 1	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	−/−	+/+	−/?
Hardener no. 2	−/−	−/−	−/−	−/−	+/+	−/−	−/−	−/÷	−/−	−/−	−/−	−/−	−/−	NT	NT	NT
Hardener no. 3	−/−	−/−	−/−	−/−	+/+	−/−	−/−	−/÷	−/−	−/−	−/−	−/−	−/−	NT	NT	NT
Specific epoxy allergens																
Epoxy resin, Bisphenol F	NT	NT	NT	NT	NT	++/÷	++/÷	NT	++/÷	NT	NT	NT	++/++	++/++	+/+	−/+
2-Phenyl glycidyl ether	NT	NT	NT	NT	NT	++/÷	++/÷	NT	−/÷	NT	NT	NT	+/+	NT	NT	NT
1,6-Hexanediol diglycidyl ether	NT	NT	NT	NT	NT	+/÷	++/÷	NT	−/÷	NT	NT	NT	+/+	NT	NT	NT
1,4-Butanediol diglycidyl ether	NT	NT	NT	NT	NT	+/÷	++/÷	NT	−/÷	NT	NT	NT	+/+	−/−	−/−	−/−

[a]Only products and components resulting in positive reactions are shown. [b]Product names are confidential and are not to be disclosed. +, ++, +++, positive; −, negative; ?, doubtful reaction; ÷, no reading; NT, not tested. Patch test reaction at D4 and D6 are separated by a solidus.

the 2-year follow-up period; neither were sensitized to epoxy components. One worker who tested positive at baseline retested positive at follow-up.

Discussion

In this study, we found that almost 9% of the production workers were sensitized to an epoxy component compared with none in the control group, and that sensitization occurred most frequently among workers with less than 1 year of exposure and among the most highly exposed workers who performed filling operations. Among nonatopic workers, a higher risk of dermatitis was suggested for those exposed to epoxy components compared with those who were nonexposed, whereas the opposite was seen for atopic workers. Sensitization was associated with dermatitis that affected about 40% of the sensitized workers. All sensitized workers were sensitized to DGEBA-R and DGEBF-R. Four of 16 participants who had a reaction to epoxy components used at the factories, did not react to the epoxy resin of the TRUE test® panel. Two of those who tested negative were also tested with the Chemotechnique epoxy series and showed a positive test result. The remaining two sensitized participants were not tested with specific epoxy allergens including DGEBF-R.

The prevalence of sensitization to DGEBA-R has been reported to vary from 0·2% to 0·5% in the general population, and up to 1·3% in patients with dermatitis.[9,10,26] The prevalence of DGEBA-R sensitization among exposed workers in our study (8·9%) is similar to the prevalence among production workers of the 2004 Danish wind turbine industry study (10·5%).[6,7] However, these two studies are not directly comparable as the 2004 study recruited production workers with dermatitis, whereas in the present study we recruited production workers with expected high risk of exposure regardless of any dermatitis.

The majority of production workers sensitized to epoxy had been employed for less than 1 year, which is in accordance with former studies and indicates a short latency period of sensitization and a healthy worker effect.[15,26] The low sensitivity of the TRUE test®, which missed one-quarter of the epoxy-sensitized participants, emphasizes the importance of tailored testing.[6,27–29]

One strength of this study is the inclusion of a control group of workers who were not exposed to epoxy components and were examined according to the same protocol as the exposed workers. All participants were tested with a tailored test series including the epoxy products handled at the workplaces. Two readings were performed 4 and 6 days after the application of the test material as recommended by the guidelines from the European Society of Contact Dermatitis.[19] None of the participants in the control group reacted to epoxy components, indicating that false positive reactions were unlikely. All patch test applications and readings were performed by the same experienced biomedical laboratory technician, which eliminated interexaminer variation. The appearance of dermatitis can fluctuate and therefore we included self-reported and clinically verified dermatitis in our case category. For all participants, information was provided about duration of exposed employment, work procedures, and amount of epoxy used, which made it possible to localize the potential risk factors at work.

This is a cross-sectional study with well-known limitations with respect to temporality between exposure and outcome. Other limitations include the low participation rate, especially among the controls, and skewed distribution of age and sex between the exposed workers and the control group, which precluded adjustment. However, sensitivity analyses of male participants showed only similar results.

Individuals with dermatitis (with no further specification) or sensitization to epoxy components are not allowed to work with epoxy products according to national worker protection legislation, whereas there are no such restrictions for office workers. Office workers are able to continue work in the presence of dermatitis, whereas production workers with dermatitis may leave employment, be transferred to nonexposed jobs or have their employment terminated as required by the legislation, leaving healthier workers in the production area. The higher prevalence of atopic dermatitis and more frequent positive patch test results to nonepoxy allergens of the TRUE test® among office workers compared with production workers are in line with healthy worker selection for those who are exposed and those who are nonexposed at the two factories, and furthermore this is expected to confound results towards the null. Therefore, we expect that we have underestimated the true impact of epoxy exposure on sensitization and dermatitis in this industry. The decreased risk of dermatitis observed for atopic workers is also indicative of selection dependent on the presence of dermatitis. Therefore, we emphasize the positive association between exposure and dermatitis suggested for the nonatopic workers.

Study participation was voluntary and may also have depended on the presence of dermatitis among exposed workers and nonexposed workers, and may have biased results in any direction. Owing to rotating shifts and absence from work, some patch test readings relied on photoassessments, but this number was small and we do not believe that this affected our results substantially.[30]

Participants were selected for this study because of their manual lamination and finishing work tasks with expected high risk of skin exposure to epoxy components. Findings are expected to reflect the risk of sensitization and dermatitis for similar work tasks, but not production work in general in the wind turbine industry.

Another limitation of this study is that we did not systematically examine participants for facial dermatitis, which is a common manifestation owing to airborne exposure to epoxy resin components in sensitized people.[31–33] This could have led to an underestimation of the prevalence of dermatitis. The study includes a limited number of workers especially in the control group, and all estimates are provided with considerable uncertainty as illustrated by the wide CIs.

In conclusion, we studied workers with high risk of skin exposure to epoxy components. The participants worked at factories with well-established and highly prioritized health and safety policies; however, these measures did not sufficiently protect them from sensitization. A possible explanation is that epoxy resin components are often translucent, leaving skin contamination unrecognized. Adding a fluorescent tracer will make resins visible and may improve the awareness of inexpedient procedures and behaviour.[34–42] Replacing current epoxy resin systems with new systems that have comparable technical properties but less skin sensitizing capacity is another novel and promising way forward to reduce the risk of skin exposure and sensitization.[43,44] Furthermore, one in four sensitized workers did not react to the epoxy resin of a baseline test panel, which emphasizes the importance of tailored testing.

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Conflicts of interest

The authors declare no conflicts of interest. Siemens Gamesa Renewable Energy financially supported a total of 50 patch tests. Siemens Gamesa Renewable Energy and Vestas Wind Systems A/S supported the study by providing test locations and access to the company as well as helping with organizational challenges associated with the study. The companies had no role in study design and data collection, and were not involved in data analysis, interpretation and conclusions. Only the authors had access to the data in this study and they take complete responsibility for the integrity of the data and the accuracy of the data analysis.

Ethics statement

The Regional Ethical Committee has approved the study (1-10-72-52-18).

Data availability

Data available on request owing to privacy/ethical restrictions.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Table S1 Specific epoxy allergens from Chemotechnique Diagnostics tested on participants from Factory 1 with a positive patch test to epoxy.

Table S2 Additional nonepoxy allergens and patch test reactivity among exposed and nonexposed workers in the wind turbine industry.

Table S3 Invited and participating study population from the wind turbine industry.

Table S4 Exposure to epoxy components and odds ratios for epoxy sensitization and dermatitis in the wind turbine industry, men only.

Table S5 Exposure to epoxy components and odds ratios for epoxy sensitization and dermatitis in the wind turbine industry, Factory 2 participants excluded.

Table S6 Exposure to epoxy components and odds ratios for dermatitis and epoxy sensitization by atopic status in the wind turbine industry, men only.

Table S7 Exposure to epoxy components and odds ratios for dermatitis and epoxy sensitization by atopy status in the wind turbine industry, Factory 2 participants excluded.

Table S8 Main chemical constituents and Chemical Abstracts Service numbers of test materials causing positive patch test results in the wind turbine industry.

References

1 Cao LY, Sood A, Taylor JS. Hand/face/neck localized pattern: sticky problems–resins. *Dermatol Clin* 2009; **27**:227–49, v.
2 Prodi A, Rui F, Fortina AB *et al.* Occupational sensitization to epoxy resins in Northeastern Italy (1996–2010). *Int J Occup Environ Health* 2015; **21**:82–7.
3 Geier J, Lessmann H, Hillen U *et al.* Sensitization to reactive diluents and hardeners in epoxy resin systems. IVDK data 2002–2011. Part I: reaction frequencies. *Contact Dermatitis* 2016; **74**: 83–93.
4 Aalto-Korte K, Pesonen M, Suuronen K. Occupational allergic contact dermatitis caused by epoxy chemicals: occupations, sensitizing products, and diagnosis. *Contact Dermatitis* 2015; **73**:336–42.
5 Caroe TK, Ebbehoj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. *Contact Dermatitis* 2014; **70**:56–62.
6 Pontén A, Carstensen O, Rasmussen K *et al.* Epoxy-based production of wind turbine rotor blades: occupational contact allergies. *Dermatitis* 2004; **15**:33–40.
7 Pontén A, Carstensen O, Rasmussen K *et al.* Epoxy-based production of wind turbine rotor blades: occupational dermatoses. *Contact Dermatitis* 2004; **50**:329–38.
8 Rasmussen K, Carstensen O, Pontén A *et al.* Risk of contact allergy and dermatitis at a wind turbine plant using epoxy resin-based plastics. *Int Arch Occup Environ Health* 2005; **78**:211–17.
9 Holness LD, Nethercott JR. Results of testing with epoxy resin in an occupational health clinic population. *Am J Contact Dermat* 1992; **3**:169–74.

10 Nielsen NH, Menne T. Allergic contact sensitization in an unselected Danish population. The Glostrup Allergy Study, Denmark. *Acta Derm Venereol* 1992; **72**:456–60.

11 Pham HQ, Marks MJ. Epoxy resins. In: *Ullmann's Encyclopedia of Industrial Chemistry*. Weinheim: Wiley-VCH, 2005.

12 The Danish Environmental Protection Agency. *Survey of Bisphenol A and Bisphenol-A-diglycidylether Polymer*. Available at: https://www2.mst.dk/Udgiv/publications/2013/04/978-87-93026-14-8.pdf (last accessed 14 August 2022).

13 Aalto-Korte K, Suuronen K, Kuuliala O *et al*. Screening occupational contact allergy to bisphenol F epoxy resin. *Contact Dermatitis* 2014; **71**:138–44.

14 Anveden Berglind I, Lind ML, Liden C. Epoxy pipe relining – an emerging contact allergy risk for workers. *Contact Dermatitis* 2012; **67**:59–65.

15 Geier J, Krautheim A, Uter W *et al*. Occupational contact allergy in the building trade in Germany: influence of preventive measures and changing exposure. *Int Arch Occup Environ Health* 2011; **84**:403–11.

16 Bregnhøj A, Søsted H, Menné T, Johansen JD. Validation of self-reporting of hand eczema among Danish hairdressing apprentices. *Contact Dermatitis* 2011; **65**:146–50.

17 Martí-Margarit A, Manresa JM, Herdman M *et al*. Valid screening questions useful to diagnose hand and forearm eczema are available in the Spanish language, a new tool for global research. *Eur J Dermatol* 2015; **25**:145–55.

18 Susitaival P, Flyvholm MA, Meding B *et al*. Nordic Occupational Skin Questionnaire (NOSQ-2002): a new tool for surveying occupational skin diseases and exposure. *Contact Dermatitis* 2003; **49**:70–6.

19 Johansen JD, Aalto-Korte K, Agner T *et al*. European Society of Contact Dermatitis guideline for diagnostic patch testing – recommendations on best practice. *Contact Dermatitis* 2015; **73**:195–221.

20 Jensen CD, Paulsen E, Andersen KE. Retrospective evaluation of the consequence of alleged patch test sensitization. *Contact Dermatitis* 2006; **55**:30–5.

21 White JM, McFadden JP, White IR. A review of 241 subjects who were patch tested twice: could fragrance mix I cause active sensitization? *Br J Dermatol* 2008; **158**:518–21.

22 Hillen U, Jappe U, Frosch PJ *et al*. Late reactions to the patch-test preparations para-phenylenediamine and epoxy resin: a prospective multicentre investigation of the German Contact Dermatitis Research Group. *Br J Dermatol* 2006; **154**:665–70.

23 Jensen CD, Andersen KE. Course of contact allergy in consecutive eczema patients patch tested with TRUE Test panels 1 and 2 at least twice over a 12-year period. *Contact Dermatitis* 2005; **52**:242–6.

24 de Groot AC. *Patch Testing*, 4th edn. Wapserveen: Acdegroot Publishing, 2018.

25 Devika S, Jeyaseelan L, Sebastian G. Analysis of sparse data in logistic regression in medical research: a newer approach. *J Postgrad Med* 2016; **62**:26–31.

26 Bangsgaard N, Thyssen JP, Menne T *et al*. Contact allergy to epoxy resin: risk occupations and consequences. *Contact Dermatitis* 2012; **67**:73–7.

27 Rømyhr O, Nyfors A, Leira HL *et al*. Allergic contact dermatitis caused by epoxy resin systems in industrial painters. *Contact Dermatitis* 2006; **55**:167–72.

28 Mowad CM. Patch testing: pitfalls and performance. *Curr Opin Allergy Clin Immunol* 2006; **6**:340–4.

29 Houle MC, Holness DL, Dekoven J, Skotnicki S. Additive value of patch testing custom epoxy materials from the workplace at the occupational disease specialty clinic in Toronto. *Dermatitis* 2012; **23**:214–19.

30 Yüksel YT, Sedeh FB, Brans R *et al*. Value of photo assessment in late patch test readings–a multicenter study from six European patch test clinics. *Contact Dermatitis* 2021; **84**:283–9.

31 Jolanki R, Kanerva L, Estlander T *et al*. Occupational dermatoses from epoxy resin compounds. *Contact Dermatitis* 1990; **23**:172–83.

32 Geier J, Lessmann H, Hillen U *et al*. An attempt to improve diagnostics of contact allergy due to epoxy resin systems. First results of the multicentre study EPOX 2002. *Contact Dermatitis* 2004; **51**:263–72.

33 Suomela S, Pesonen M, Ylinen K *et al*. Characterization of patients with occupational allergy to two new epoxy hardener compounds. *Contact Dermatitis* 2022; **87**:81–88.

34 Behroozy A. On dermal exposure assessment. *Int J Occup Environ Med* 2013; **4**:113–27.

35 Aragon A, Blanco L, Lopez L *et al*. Reliability of a visual scoring system with fluorescent tracers to assess dermal pesticide exposure. *Ann Occup Hyg* 2004; **48**:601–6.

36 Aragón A, Blanco LE, Funez A *et al*. Assessment of dermal pesticide exposure with fluorescent tracer: a modification of a visual scoring system for developing countries. *Ann Occup Hyg* 2006; **50**:75–83.

37 Fenske RA, Leffingwell JT, Spear RC. A video imaging technique for assessing dermal exposure. I. Instrument design and testing. *Am Ind Hyg Assoc J* 1986; **47**:764–70.

38 Fenske RA, Wong SM, Leffingwell JT *et al*. A video imaging technique for assessing dermal exposure. II. Fluorescent tracer testing. *Am Ind Hyg Assoc J* 1986; **47**:771–5.

39 Cherrie JW, Brouwer DH, Roff M *et al*. Use of qualitative and quantitative fluorescence techniques to assess dermal exposure. *Ann Occup Hyg* 2000; **44**:519–22.

40 Bierman EP, Brouwer DH, Van Hemmen JJ. Implementation and evaluation of the fluorescent tracer technique in greenhouse exposure studies. *Ann Occup Hyg* 1998; **42**:467–75.

41 Hautemaniere A, Diguio N, Daval MC *et al*. Short-term assessment of training of medical students in the use of alcohol-based hand rub using fluorescent-labeled hand rub and skin hydration measurements. *Am J Infect Control* 2009; **37**:338–40.

42 Kromhout H, Hoek F, Uitterhoeve R *et al*. Postulating a dermal pathway for exposure to anti-neoplastic drugs among hospital workers. Applying a conceptual model to the results of three workplace surveys. *Ann Occup Hyg* 2000; **44**:551–60.

43 Hagvall L, Niklasson IB, Rudback J *et al*. Assessment of cross-reactivity of new less sensitizing epoxy resin monomers in epoxy resin-allergic individuals. *Contact Dermatitis* 2016; **75**:144–50.

44 O'Boyle NM, Niklasson IB, Ponting DJ *et al*. Nature-derived epoxy resins: synthesis, allergenicity, and thermosetting properties of pinoresinol diglycidyl ether. *Toxicol Ind Health* 2022; **38**:259–69.

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ORIGINAL ARTICLE

CONTACT DERMATITIS | WILEY

Occupational exposure to epoxy components and risk of dermatitis: A registry-based follow-up study of the wind turbine industry

Alexandra Golabek Christiansen[1] | Martin Byskov Kinnerup[1,2] | Ole Carstensen[2] | Mette Sommerlund[3] | Per Axel Clausen[4] | Jakob Hjort Bønløkke[5] | Vivi Schlünssen[6] | Marléne Isaksson[7] | Sigrun Alba Johannesdottir Schmidt[3,8] | Henrik Albert Kolstad[1,9]

[1]Department of Occupational Medicine, Danish Ramazzini Centre, Aarhus University Hospital, Aarhus, Denmark

[2]Department of Occupational Medicine, Danish Ramazzini Centre, The Regional Hospital Goedstrup, University Research Clinic, Herning, Denmark

[3]Department of Dermatology, Aarhus University Hospital, Aarhus, Denmark

[4]National Research Centre for the Working Environment, Copenhagen, Denmark

[5]Department of Occupational and Environmental Medicine, Danish Ramazzini Centre, Aalborg University Hospital, Aalborg, Denmark

[6]Department of Public Health, Research Unit for Environment, Occupation and Health, Danish Ramazzini Centre, Aarhus University, Aarhus, Denmark

[7]Department of Occupational and Environmental Dermatology, Skane University Hospital Malmö, Lund University, Malmö, Sweden

[8]Department of Clinical Epidemiology, Aarhus University Hospital, Aarhus, Denmark

[9]Institute of Clinical Medicine, Aarhus University, Aarhus, Denmark

Correspondence
Alexandra Golabek Christiansen, Department of Occupational Medicine, Aarhus University Hospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N, Denmark.
Email: alexpe@rm.dk

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Abstract

Background: Allergic contact allergy and dermatitis are frequently reported among epoxy-exposed workers.

Objectives: To determine the risk of dermatitis associated with epoxy exposure.

Methods: We followed 825 epoxy-exposed and 1091 non-exposed blue-collar workers, and 493 white-collar workers of a Danish wind turbine blade factory during 2017–2022 with linked data from national health registers on diagnoses, patch testing, or fillings of prescriptions for topical corticosteroids. Incidence rate ratios of dermatitis or a first-time topical corticosteroid prescription were estimated with Poisson regression using non-exposed blue-collar workers as reference. We similarly estimated incidence rate ratios for the duration of epoxy exposure and current epoxy exposure.

Results: Epoxy-exposed blue-collar workers showed a dermatitis incidence rate of 2.1 per 100 000 person days, a two-fold increased risk of dermatitis and a 20% increased risk of filling a prescription for topical corticosteroids. Incidence rate ratios were higher during early exposure and declined with further exposure for both outcomes. White-collar workers had generally lower risks.

Conclusion: We observed an increased risk of dermatitis following epoxy exposure confirming previous case reports and cross-sectional studies emphasizing the need for intensified focus on preventive efforts for this group of workers.

KEYWORDS
allergic contact dermatitis, epidemiology, epoxy resin systems, occupational

1 | INTRODUCTION

Epoxy resin systems were introduced in the 1940s and shortly thereafter, the first cases of epoxy sensitization and dermatitis were described.[1–4] Epoxy components are now well-known sensitizers of the skin and a common cause of allergic contact dermatitis.[5–7] Contact dermatitis has frequently been observed among workers exposed to epoxy components within construction, electronics, painting and in the manufacturing of aircraft and wind turbines[7–12] and more often among blue than among white-collar workers.[13,14] Due to this, comprehensive protective equipment is required and the Danish Working Environment Authority requires workers handling epoxy components to be certified for this work.[7]

Wind energy is an emerging sustainable energy source and in Denmark, the wind turbine industry is the major consumer of epoxy resin systems.[15] This industry has a high recognition rate for contact dermatitis as an occupational disease.[12,16] In 2004, high prevalences of sensitization and dermatitis were observed among epoxy-exposed workers of the wind turbine industry.[17–19] In a recent cross-sectional study, we observed an 8.9% prevalence of sensitization and a 16.4% prevalence of dermatitis among non-atopic epoxy-exposed workers in the industry.[14] Among office workers, constituting a non-exposed reference group, none were sensitized and 6.5% had dermatitis.

Many of the previous epidemiological studies on this topic are case reports, studies with self-reported exposure information, crude registry-based exposure or outcome information, or cross-sectional designs with voluntary participation and no reference groups.[4,12,16,19]

The objective of this cohort study was to analyse the incidence of dermatitis over time comparing workers with detailed information on epoxy exposure with a reference cohort of non-exposed workers.

2 | METHODS

2.1 | Setting

2.1.1 | Dermatitis diagnoses in the Danish healthcare sector

In Denmark, dermatitis is usually diagnosed and treated by general practitioners, but they do not provide diagnostic information to the national registers.[20] Complicated, occupationally related cases, or cases requiring further diagnostic procedures, such as a patch test, will be referred to a hospital or a private dermatology clinic, where data are routinely collected in the national registers. Mild topical corticosteroids (hydrocortisone) are available over the counter at pharmacies, whereas more potent topical corticosteroids require a prescription from a medical doctor.

2.1.2 | Work procedures in the wind turbine industry

The epoxy-exposed workers of this study were primarily doing lamination or filling procedures. Lamination is characterized by removing large casting defects of the wind turbine blades and re-establishing the surface by hand lamination. Using a handheld roller, fibreglass mats are embedded with clear liquid epoxy. The filling procedure is used to repair smaller defects with a viscous epoxy filler that is smoothened with a scraper. It is mandatory for workers to wear a protective suit with a hood, face shield, protective glasses, safety shoes and often an apron, protective arm sleeves and chemically resistant disposable nitrile-rubber gloves tested for permeability against the relevant product and procedure. Around one third of the non-exposed blue-collar workers handled fibreglass mats manually during a significant part of the work day. Besides this, there is limited exposure to skin irritants in the non-exposed blue-collar workers. The epoxy-exposed work tasks are physically demanding, the worker turnover is high and the workers are young (as shown later).

2.2 | Study population

We established the study population from company files provided by a wind turbine blade factory in Denmark holding information on all workers employed at any time between 1 January 2017 and 1 April 2022. We excluded workers patch tested or diagnosed with dermatitis before the start of follow-up, as defined later, or two or more prescriptions for topical corticosteroids within 5 years before the start of follow-up to avoid including workers with prevalent dermatitis. We excluded workers not included in The Danish Occupational Cohort (DOC*X) cohort because our outcome and covariate data were obtained for members of this cohort.[21] DOC*X includes ever gainfully employed people in Denmark from 1976 to 2019; thus, we did not include workers for the current analyses who first entered the labour market after 2019. We excluded workers with no valid civil registration number, emigrating before begin of follow-up

and women because very few were exposed to epoxy components. Workers first employed in the study factory after 30 June 2021 were also excluded as this was the last date with outcome information.

Using the unique civil registration number assigned to all Danish residents, we linked the study population to individual-level information from the DOC*X,[21] the Civil Registration System, the Danish National Patient Registry,[22] the Danish National Health Service Register,[23] the Danish National Prescription Registry[24,25] and the Population Education Registry.[26]

2.3 | Exposure

The factory provided full employment history for each worker with information on occupational status within the factory (blue- or white-collar worker) and departments (epoxy production, no epoxy production) with starting and ending dates for each assignment. Occupational status and department could change during employment and hence every worker could move in and out of different combinations of occupational status and department over time. In the overall analyses, for each day of follow-up, exposure status was classified as a white-collar worker from the first date as a white-collar worker, as a non-exposed blue-collar worker from the first date of employment in a department with no epoxy production, and as exposed blue-collar worker from the first date of employment in a department with epoxy production. Hence, in the overall analyses, exposed blue-collar employment overruled any subsequent non-exposed blue-collar employment, which overruled any subsequent white-collar employment.

In analyses restricted to blue-collar workers, we recorded duration of exposure as the cumulative number of days in exposed employment. To elucidate the impact of current exposure, we recorded any exposed employment occurring within the previous 60 days, while any exposure outside this window was disregarded.[27]

2.4 | Outcomes

Outcomes were obtained from three national health registers. The Danish National Patient Registry has detailed information on all patients discharged from Danish hospitals since 1977 and outpatient hospital contacts since 1995.[22] For each contact, primary and optional secondary diagnoses are recorded according to the International Classification of Diseases 8th revision (ICD-8) during 1977–1993 and ICD-10 during 1994–2022, as well as information on procedures coded according to SKS, which is a Danish healthcare classification system.

The Danish National Health Service Register contains information on consultations with health contractors in primary healthcare, including private practicing dermatologists, supported by public health insurance since 1990.[23] The register contains information on specialty, the purpose of the consultation and patch testing procedure that were available for this study from 1 April 2017.

The Danish National Prescription Registry contains individual-level information on all prescriptions filled in community pharmacies with information on the Anatomical Therapeutic Chemical Classification System together with the date of filling, since 1994.[24] We had a complete follow-up for the three registers until and including 30 June 2021.

2.4.1 | Dermatitis

We defined dermatitis as having either a primary or a secondary inpatient or outpatient hospital diagnosis of dermatitis, a hospital patch test procedure, a private dermatology clinic consultation for 'atopic dermatitis, hand eczema or psoriasis' (these conditions are not coded separately), or a private dermatology clinic patch test. We defined the onset date as the date of hospital admission, first outpatient visit or dermatology clinic consultation.

2.4.2 | Topical corticosteroids

Topical corticosteroids are the first-line treatment for dermatitis. In an attempt to capture workers who developed contact dermatitis but who had not (yet) received a specialist diagnosis or patch test, we included a secondary outcome defined as filling one or more prescriptions for topical corticosteroids alone or in combination with anti-infectives. Because of our eligibililty criteria, the washout period was 5 years (the 5 years before start of follow-up). We considered the first date of filling to be the date of onset in this analysis. Detailed definitions are provided in Table S1.

2.5 | Other characteristics

Information about educational level and specific occupation at the start of follow-up was provided by DOC*X based on data from Statistics Denmark and coded according to DISCO-88, the Danish version of the International Standard Classification of Occupations, ISCO 1988.[21] If the DISCO-88 code was missing in the first year of employment at the factory, the latest valid code was assigned ($n = 159$ [6.6%]). Educational level was grouped into lower and upper secondary, short cycle tertiary, bachelor, master, doctoral or equivalent based on the international standard classification. Information on age and sex was obtained from the Civil Registration System.

2.6 | Statistical analyses

We followed each worker from 1 January 2017, or the day of first employment until onset of dermatitis, death, emigration, disappearance or end of follow-up by 30 June 2021, whichever occurred first. In the secondary analysis, we followed workers until their first filled

prescription for topical corticosteroids, death, emigration, disappearance or end of follow-up by 30 June 2021, whichever occurred first.

We treated exposure status, duration of exposure and current exposure as time-varying variables and estimated incidence rate ratios (IRR) with 95% confidence intervals (CI) as the number of outcomes per person-days of follow-up with Poisson regression. Analyses were adjusted for age (<30, 30–39, 40–49, ≥50 years). Information on educational level and specific occupation was not included in the statistical analyses due to similar educational level among exposed and non-exposed blue-collar workers (as shown later) and the limited number of events in some of the analyses.

In the overall analyses and analyses of cumulative exposure, we used the non-exposed blue-collar workers as the reference. Five categories of duration of exposure were defined: 0, 1, 2, 3 and ≥4 years, 1 year defined as 365 days. Current exposure was defined as ever versus never exposure within the last 60 days regardless of the duration of exposure.

We fitted restricted cubic splines with 95% CIs for the duration of exposure as a continuous variable, placing the knots at the 5, 50 and 95 percentiles.[28] These analyses only included the blue-collar workers exposed for at least 1 day (excluding the null-exposed blue-collar workers as well as the white-collar workers).

In a sensitivity analysis, we required at least two fillings of a prescription for topical corticosteroids to be classified as an event. The statistical analyses were performed using Stata version 17.0 (StataCorp, College Station, TX).

This study was registered at the repository of the Central Denmark Region (J. no. 2012-58-006/Case no. 1-16-02-125-200). Register studies in Denmark without biological materials do not need approval from the National Committee of Health Research Ethics or informed consent. All data were analysed at the server of Statistics Denmark and we had only access to pseudonymized data that were handled according to the rules of Statistics Denmark. In agreement with the EU General Data Protection Regulations (GDPR), we did not report on groups of three or less persons.

3 | RESULTS

Among the eligible 3459 workers, we excluded 56 workers patch tested or diagnosed with dermatitis before the start of follow-up, 275 with two or more prescriptions for topical corticosteroids within 5 years before start of follow-up, 477 women and 242 for other reasons (Figure S1, Table S2). This left 2409 workers (69.6%) for further analyses.

3.1 | Baseline characteristics

Exposed blue-collar workers were younger than non-exposed blue-collar workers and white-collar workers (Table 1). Specific occupation and highest achieved education were similar for exposed and non-exposed blue-collar workers, the majority being plant and machine operators and assemblers, and having upper secondary education. White-collar workers were more often professionals, technicians and associate professionals and had a bachelor, master or equivalent as the highest achieved education. Excluded and included workers were comparable with respect to specific occupations and educational levels (Table S3). Slightly more blue-collar workers than white-collar workers were excluded because of prior dermatitis or filling a prescription for topical corticosteroids, while little differences were seen between exposed and non-exposed blue-collar workers (Table S2).

3.2 | Dermatitis

We identified 41 dermatitis events during 3 384 675 person-days of follow-up (median 1641 days; interquartile range: 1144–1641 days) at an incidence rate of 1.2 per 100 000 person-days. In the secondary analysis, we identified 353 topical corticosteroid events during 3 115 927 person-days of follow-up (median: 1641 days; interquartile range: 1003–1641 days), yielding an incidence rate of 11.3 per 100 000 person-days. A total of 21 dermatitis events (51.2%) were identified at a hospital. Eight of these (all epoxy-exposed), were diagnosed at a department of occupational medicine. The majority of hospital diagnoses of dermatitis fell within subgroups of 'allergic contact dermatitis' and 'other dermatitis'.

The incidence rates of dermatitis were 2.1, 0.8 and 0.5 per 100 000 person-days for exposed blue-collar workers, non-exposed blue-collar workers and white-collar workers, respectively. With non-exposed blue-collar workers as a reference, we thus observed a two-fold increased IRR (adjusted) for exposed blue-collar workers (IRR: 2.4, 95% CI: 1.2–5.0) but a decreased IRR (IRR: 0.6, 95% CI: 0.2–2.1) among white-collar workers (Table 2).

The blue-collar workers exposed for less than 1 year (1–365 days) showed an IRR of 3.7 (13 events, 95% CI: 1.6–8.6) compared with the non-exposed blue-collar workers (Table 2). The mean time from start of follow-up until onset of dermatitis within the first year was 191 days. The IRR decreased monotonically with a longer duration of exposure (Table 2; Figure 1). The IRR of dermatitis was 2.9 (95% CI: 1.5–5.9) among blue-collar workers with current exposure (during the previous 1–60 days) compared with non-exposed blue-collar workers.

3.3 | Prescribed corticosteroids

We observed IRs for filling a prescription for topical corticosteroids of 13.0, 11.4 and 7.9 per 100 000 person-days for exposed blue-collar workers, non-exposed blue-collar workers and white-collar workers. The IRRs were 1.2 (95% CI: 0.9–1.5) for exposed blue-collar workers and 0.7 (95% CI: 0.5–1.0) for white-collar workers compared with the non-exposed blue-collar workers. The highest IRR of 1.5 (66 events, 95% CI: 1.1–2.0) was seen for those exposed less than 1 year (1–365 days), while no increased risk was seen for a longer duration of exposure. The IRR decreased monotonically with a longer duration of exposure (Figure 2). The mean time from start of follow-up until filling of a prescription for

TABLE 1 Characteristics of the study population by exposure status to epoxy components, male wind turbine blade workers, 2017–2021.

Characteristics	Exposure status		
	Exposed blue-collar worker, *N* = 825	Non-exposed blue-collar worker, *N* = 1091	White-collar worker, *N* = 493
Age, years			
Median, interquartile range	29 (26–37)	40 (31–49)	37 (30–46)
Age group, *n* (column %)			
<30 years	415 (50.3)	207 (19.0)	114 (23.1)
30–39 years	234 (28.4)	334 (30.6)	164 (33.3)
40–49 years	113 (13.7)	284 (26.0)	130 (26.4)
≥50	63 (7.6)	266 (24.4)	85 (17.2)
Occupation (DISCO-88)[a]			
Legislators, senior officials and managers (Major Group 1)	4 (0.5)	5 (0.5)	117 (23.7)
Professionals (Major Group 2); technicians and associate professionals (Major Group 3)	15 (1.8)	16 (1.5)	284 (57.6)
Clerks (Major Group 4)	17 (2.1)	15 (1.4)	35 (7.1)
Service workers and shop and market sales workers (Major Group 5)	43 (5.2)	26 (2.4)	13 (2.6)
Skilled agricultural and fishery workers (Major Group 6); craft and related trades workers (Major Group 7)	95 (11.5)	60 (5.5)	13 (2.6)
Plant and machine operators and assemblers (Major Group 8)	518 (62.8)	865 (79.3)	4 (0.8)
Armed forces (Major Group 0); elementary occupations (Major Group 9)	133 (16.1)	104 (9.5)	27 (5.5)
Highest achieved education			
Lower secondary	214 (25.9)	315 (28.9)	41 (8.3)
Upper secondary	561 (68.0)	703 (64.4)	148 (30.0)
Short cycle tertiary	15 (1.8)	33 (3.0)	35 (7.1)
Bachelor or equivalent	19 (2.3)	17 (1.6)	94 (19.1)
Master or equivalent	6 (0.7)	9 (0.8)	157 (31.8)
Doctoral or equivalent	0 (0.0)	0 (0.0)	18 (3.7)
Missing	10 (1.2)	14 (1.3)	0 (0.0)

[a]Grouped according to International Standard Classification of Occupation, ISCO-88.

topical corticosteroids within the first year was 152 days. Current exposure showed an IRR of 1.3 (95% CI: 1.0–1.7). The sensitivity analysis defining an event as two or more fillings of prescriptions for topical corticosteroids yielded similar results (Table S4).

4 | DISCUSSION

We observed an increased risk of dermatitis or filling a prescription for topical corticosteroids following epoxy exposure, although the association was less pronounced for topical corticosteroids. Both outcomes showed the highest risks during early exposure and declined thereafter despite continued exposure. Exposure within the previous 60 days showed increased risks of dermatitis and filling a prescription for topical corticosteroids, slightly higher than the overall findings for both outcomes. White-collar workers had a generally lower risk compared with non-exposed blue-collar workers.

The results of this longitudinal study are in accordance with the increased risk of dermatitis and skin sensitization observed in non-atopic workers in our recent cross-sectional study of a subsample of the current study population with patch test data on 221 workers.[14] Multiple former studies also reported high prevalences of dermatitis and sensitization among epoxy-exposed workers.[7–13,16,19]

The declining risk of dermatitis and filling of prescriptions for topical corticosteroids with increasing duration of exposure is consistent with our previous as well as other studies.[7,14,29] This indicates a short latency period but also a healthy worker survivor effect. Workers with dermatitis move to other parts of production within the factory without epoxy exposure or leave the factory before consulting a physician or filling a prescription for topical corticosteroids.[30]

TABLE 2 Epoxy exposure, incidence rates (IR) per 100 000 person-days, crude and age-adjusted incidence rate ratios (IRR) of dermatitis and filling of a prescription for topical corticosteroids, male wind turbine blade workers, 2017–2021.

	Dermatitis ($n = 41$)					Prescription for topical corticosteroids ($n = 353$)				
Epoxy exposure	**Person-days**	**Events**	**IR**	**IRR_{crude}**	**IRR_{adj}**	**Person-days**	**Events**	**IR**	**IRR_{crude}**	**IRR_{adj}**
All workers										
Exposed blue-collar workers	1 297 107	27	2.1	2.7 (1.4–5.5)	2.4 (1.2–5.0)	1 188 983	154	13.0	1.1 (0.9–1.4)	1.2 (0.9–1.5)
Non-exposed blue-collar workers	1 442 355	11	0.8	Reference	Reference	1 321 790	151	11.4	Reference	Reference
White-collar workers	645 213	3	0.5	0.6 (0.2–2.2)	0.6 (0.2–2.1)	605 154	48	7.9	0.7 (0.5–1.0)	0.7 (0.5–1.0)
Blue-collar workers only										
Duration of exposure (years)										
0	1 442 355	11	0.8	Reference	Reference	1 321 790	151	11.4	Reference	Reference
1	417 813	13	3.1	4.1 (1.8–9.1)	3.7 (1.6–8.6)	392 219	66	16.8	1.5 (1.1–2.0)	1.5 (1.1–2.0)
2	339 564	5	1.5	1.9 (0.7–5.6)	1.8 (0.6–5.2)	315 733	36	11.4	1.0 (0.7–1.4)	1.0 (0.7–1.5)
3	261 683	5	1.9	2.5 (0.9–7.2)	2.3 (0.8–6.8)	239 952	28	11.7	1.0 (0.7–1.5)	1.0 (0.7–1.5)
≥4	278 047	4	1.4	1.9 (0.6–5.9)	1.8 (0.6–5.6)	241 079	24	10.0	0.9 (0.5–1.3)	0.9 (0.6–1.4)
Current exposure										
Exposure	900 805	23	2.6	3.1 (1.6–6.0)	2.9 (1.5–5.9)	828 344	119	14.4	1.3 (1.0–1.6)	1.3 (1.0–1.7)
No exposure	1 838 657	15	0.8	Reference	Reference	1 682 429	186	11.1	Reference	Reference

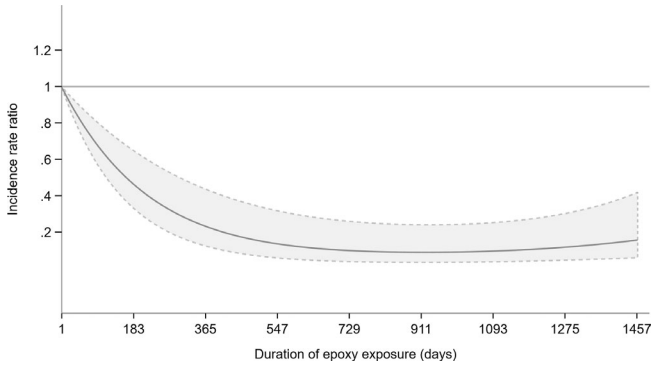

FIGURE 1 Age-adjusted incidence rate ratios of dermatitis associated with the duration of epoxy exposure entered as a restricted cubic spline model, male wind turbine workers, 2017–2021. The solid line represents the point estimate and dotted lines mark 95% confidence intervals.

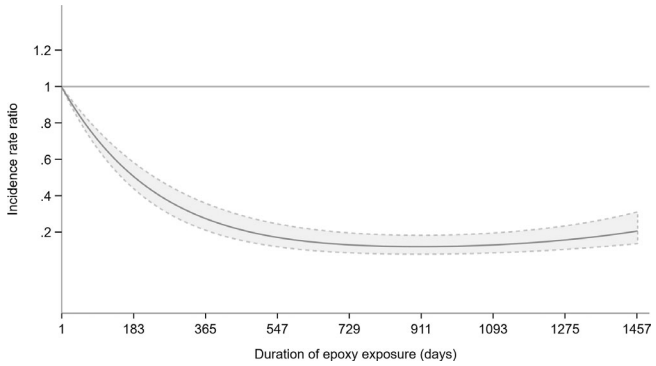

FIGURE 2 Age-adjusted incidence rate ratios of first filled prescription for topical corticosteroids associated with the duration of epoxy exposure entered as a restricted cubic spline model, male wind turbine workers, 2017–2021. The solid line represents the point estimate and dotted lines mark 95% confidence intervals.

4.1 | Strengths and limitations

A major strength of this study is the access to all exposed and non-exposed workers of the study population during the follow-up period. Participation should thus be complete and unaffected by self-selection dependent on a history of dermatitis that may have biased earlier studies relying on voluntary participation.[14,18]

We obtained data on dermatitis and filling of topical corticosteroid prescriptions from national registers with high coverage[22,24] collected within a tax-funded health care system, limiting the impact of social factors on data quality.

No information on dermatitis was available directly from the workers or from the general practitioners. The incompleteness of such cases, which are likely less severe, is indicated by the much higher number of outcome events when using our secondary outcome based on prescriptions for topical corticosteroids. We would expect such under-reporting to affect the exposed and non-exposed blue-collar workers equally unless the threshold for referral to a hospital or dermatology clinic was lower (or higher) for epoxy-exposed patients than for the non-exposed. The high number of exposed dermatitis cases and the lack of non-exposed cases diagnosed at departments of occupational medicine may indicate a lower threshold for the exposed patients because most patients are referred if an occupational cause is suspected. This suggests that we have overestimated the association between epoxy exposure and dermatitis.

Our results for topical corticosteroids should, on the other hand, not be affected by such referral bias and showed weaker associations with epoxy exposure. These results could partly be explained by non-differential misclassification and bias towards the null due to the inclusion of filling a prescription for topical corticosteroids prescribed for other dermatoses than dermatitis, for example, psoriasis.

The access to day-by-day information on epoxy exposure from a company register with high validity allowed analyses of precise exposure timing and exposure–response relations, which to our knowledge have not been done before for epoxy exposure or other skin sensitizers.

The reference group was non-exposed blue-collar workers employed at the same factory and with comparable levels of education and specific occupations as the exposed blue-collar workers. Furthermore, a comparable number of exposed and non-exposed blue-collar workers were excluded because of dermatitis or topical corticosteroid use before the start of follow-up indicating comparable underlying risks of dermatitis for the two cohorts. The exposed blue-collar workers were on average 11 years younger than the non-exposed blue-collar workers, which we accounted for by the age-adjusted analyses. Taken together, we consider residual and unmeasured confounding unlikely in contrast to our recent study that included a reference group of white-collar workers who differed from the epoxy-exposed workers with respect to atopy, sex, age and educational level.[14]

One third of the non-exposed blue-collar workers handled fibreglass mats manually during a significant part of the work day. Glass fibres are well-documented skin irritants[31] and this may have confounded our results towards the null.

4.2 | Putative mechanisms and generalizability

As results from patch tests or other clinical data were unavailable, we could not examine the mechanism behind our findings. Epoxy components have strong sensitizing properties and sensitization is the most likely mechanism of the observed increased risk of dermatitis. However, epoxy components are also irritants, and irritation may also, at least partly, explain our findings.[9,11,13,14,18,32,33] We find that the results should be valid for other worker populations with comparable work with epoxy resin systems.

5 | CONCLUSION

We found an increased risk of dermatitis following epoxy exposure showing an inverse exposure-response relation with increasing

duration of exposure, in accordance with a short latency period and a strong healthy worker survivor effect.

In the short run, industries using epoxy components and occupational health and safety institutions should put increased focus on appropriate training of newly appointed workers including correct use of personal protective equipment. In the long run, they should consider epoxy resin systems with reduced sensitizing potential and improve exposure surveillance by visualizing skin contamination by adding UV tracers to the epoxy components.[34–38]

AUTHOR CONTRIBUTIONS

Alexandra Golabek Christiansen: Conceptualization; formal analysis; funding acquisition; investigation; methodology; project administration; visualization; writing – original draft; writing – review and editing. **Martin Byskov Kinnerup:** Data curation; formal analysis; software; visualization; writing – review and editing. **Ole Carstensen:** Funding acquisition; writing – review and editing. **Mette Sommerlund:** Funding acquisition; writing – review and editing. **Per Axel Clausen:** Writing – review and editing; funding acquisition. **Jakob Hjort Bønløkke:** Funding acquisition; writing – review and editing. **Vivi Schlünssen:** Funding acquisition; writing – review and editing. **Marléne Isaksson:** Funding acquisition; writing – review and editing. **Sigrun Alba Johannesdottir Schmidt:** Methodology; writing – review and editing. **Henrik Albert Kolstad:** Formal analysis; conceptualization; funding acquisition; investigation; methodology; project administration; supervision; writing – original draft; writing – review and editing.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest. Siemens Gamesa Renewable Energy provided data for this study. The company had no role in study design, data collection and were *not* involved in data analysis, interpretation and conclusion. Only the authors had access to the data in this study and take complete responsibility for the integrity of the data and the accuracy of the data analysis.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Register studies not including biological human material or sensitive bio informative data does not require ethical approvement in Denmark. This study was registered at the repository of Central Denmark Region (J. no. 2012-58-006/Case no. 1-16-02-125-200).

ORCID

Alexandra Golabek Christiansen https://orcid.org/0000-0003-1787-6669

Marléne Isaksson https://orcid.org/0000-0002-9005-0962

Henrik Albert Kolstad https://orcid.org/0000-0002-6535-4323

REFERENCES

1. Morris GE. Epoxy resins; their uses and chemical and dermatological aspects. *AMA Arch Derm*. 1957;76(6):757-761. doi:10.1001/archderm.1957.01550240075014
2. Grandjean E. The danger of dermatoses due to cold-setting ethoxyline resins (epoxide resins). *Br J Ind Med*. 1957;14(1):1-4. doi:10.1136/oem.14.1.1
3. Savitt LE. Contact dermatitis encountered in the production of epoxy resins. *AMA Arch Derm*. 1955;71(2):212-213. doi:10.1001/archderm.1955.01540260070014
4. Gaul LE. Epoxy dermatitis from installing cathodic protection. *Arch Dermatol*. 1962;86:77. doi:10.1001/archderm.1962.01590070083015
5. Aalto-Korte K, Pesonen M, Suuronen K. Occupational allergic contact dermatitis caused by epoxy chemicals: occupations, sensitizing products, and diagnosis. *Contact Dermatitis*. 2015;73(6):336-342. doi:10.1111/cod.12445
6. Geier J, Lessmann H, Hillen U, Skudlik C, Jappe U. Sensitization to reactive diluents and hardeners in epoxy resin systems. IVDK data 2002–2011. Part I: reaction frequencies. *Contact dermatitis*. 2016;74(2):83-93. doi:10.1111/cod.12491
7. Bangsgaard N, Thyssen JP, Menne T, et al. Contact allergy to epoxy resin: risk occupations and consequences. *Contact Dermatitis*. 2012;67(2):73-77. doi:10.1111/j.1600-0536.2012.02072.x
8. Romyhr O, Nyfors A, Leira HL, Smedbold HT. Allergic contact dermatitis caused by epoxy resin systems in industrial painters. *Contact Dermatitis*. 2006;55(3):167-172.
9. van Putten PB, Coenraads PJ, Nater JP. Hand dermatoses and contact allergic reactions in construction workers exposed to epoxy resins. *Contact Dermatitis*. 1984;10(3):146-150. doi:10.1111/j.1600-0536.1984.tb00020.x
10. Spee T, Timmerman JG, Ruhl R, Kersting K, Heederik DJ, Smit LA. Determinants of epoxy allergy in the construction industry: a case-control study. *Contact Dermatitis*. 2016;74(5):259-266. doi:10.1111/cod.12529
11. Loranger C, Moreau L, Sasseville D. Occupational contact dermatitis in the Canadian aircraft industry. *Dermatitis*. 2018;29(3):139-150. doi:10.1097/DER.0000000000000361
12. Caroe TK, Ebbehoj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. *Contact Dermatitis*. 2014;70(1):56-62. doi:10.1111/cod.12134
13. Schwensen JF, Menne T, Veien NK, et al. Occupational contact dermatitis in blue-collar workers: results from a multicentre study from the Danish contact dermatitis group (2003–2012). *Contact Dermatitis*. 2014;71(6):348-355. doi:10.1111/cod.12277
14. Christiansen AG, Carstensen O, Sommerlund M, et al. Prevalence of skin sensitisation and dermatitis among epoxy-exposed workers in the wind turbine industry. *Br J Dermatol*. 2022;187:988-996. doi:10.1111/bjd.21830
15. Arbejdsmiljørådet. Arbejdsmiljørådets anbefalinger vedrørende epoxy og isocyanater. 2016. https://amr.dk/media/18588/amrs-anbefalinger-vedr-epoxy-og-isocyanater.pdf
16. Dietz JB, Menne T, Meyer HW, et al. Incidence rates of occupational contact dermatitis in Denmark between 2007 and 2018: a population-based study. *Contact Dermatitis*. 2021;85(4):421-428. doi:10.1111/cod.13910

17. Pontén A, Carstensen O, Rasmussen K, Gruvberger B, Isaksson M, Bruze M. Epoxy-based production of wind turbine rotor blades: occupational contact allergies. *Dermatitis*. 2004;15(1):33-40.
18. Pontén A, Carstensen O, Rasmussen K, Gruvberger B, Isaksson M, Bruze M. Epoxy-based production of wind turbine rotor blades: occupational dermatoses. *Contact Dermatitis*. 2004;50(6):329-338. doi:10.1111/j.0105-1873.2004.00346.x
19. Rasmussen K, Carstensen O, Pontén A, Gruvberger B, Isaksson M, Bruze M. Risk of contact allergy and dermatitis at a wind turbine plant using epoxy resin-based plastics. *Int Arch Occup Environ Health*. 2005;78(3):211-217. doi:10.1007/s00420-004-0575-5
20. Schmidt M, Schmidt SAJ, Adelborg K, et al. The Danish health care system and epidemiological research: from health care contacts to database records. *Clin Epidemiol*. 2019;11:563-591. doi:10.2147/CLEP.S179083
21. Flachs EM, Petersen SEB, Kolstad HA, et al. Cohort profile: DOC*X: a nationwide Danish occupational cohort with eXposure data—an open research resource. *Int J Epidemiol*. 2019;48(5):1413-1413k. doi:10.1093/ije/dyz110
22. Schmidt M, Schmidt SA, Sandegaard JL, Ehrenstein V, Pedersen L, Sorensen HT. The Danish National Patient Registry: a review of content, data quality, and research potential. *Clin Epidemiol*. 2015;7:449-490. doi:10.2147/CLEP.S91125
23. Andersen JS, Olivarius Nde F, Krasnik A. The Danish National Health Service Register. *Scand J Public Health*. 2011;39(7 Suppl):34-37. doi:10.1177/1403494810394718
24. Kildemoes HW, Sorensen HT, Hallas J. The Danish National Prescription Registry. *Scand J Public Health*. 2011;39(7 Suppl):38-41. doi:10.1177/1403494810394717
25. Pottegard A, Schmidt SAJ, Wallach-Kildemoes H, Sorensen HT, Hallas J, Schmidt M. Data resource profile: the Danish National Prescription Registry. *Int J Epidemiol*. 2017;46(3):798-798f. doi:10.1093/ije/dyw213
26. Thygesen LC, Daasnes C, Thaulow I, Bronnum-Hansen H. Introduction to Danish (nationwide) registers on health and social issues: structure, access, legislation, and archiving. *Scand J Public Health*. 2011;39(7 Suppl):12-16. doi:10.1177/1403494811399956
27. Checkoway H, Pearce N, Hickey JL, Dement JM. Latency analysis in occupational epidemiology. *Arch Environ Health*. 1990;45(2):95-100. doi:10.1080/00039896.1990.9935932
28. Desquilbet L, Mariotti F. Dose-response analyses using restricted cubic spline functions in public health research. *Stat Med*. 2010;29(9):1037-1057. doi:10.1002/sim.3841
29. Jolanki R, Kanerva L, Estlander T, Tarvainen K, Keskinen H, Henriks-Eckerman ML. Occupational dermatoses from epoxy resin compounds. *Contact Dermatitis*. 1990;23(3):172-183.
30. Arrighi HM, Hertz-Picciotto I. The evolving concept of the healthy worker survivor effect. *Epidemiology*. 1994;5(2):189-196. doi:10.1097/00001648-199403000-00009
31. Camacho I, Rajabi-Estarabadi A, Eber AE, et al. Fiberglass dermatitis: clinical presentations, prevention, and treatment—a review of literatures. *Int J Dermatol*. 2019;58(10):1107-1111. doi:10.1111/ijd.14407
32. Jolanki R, Tarvainen K, Tatar T, et al. Occupational dermatoses from exposure to epoxy resin compounds in a ski factory. *Contact Dermatitis*. 1996;34(6):390-396. doi:10.1111/j.1600-0536.1996.tb02239.x
33. Tarvainen K, Kanerva L, Jolanki R, Estlander T. Occupational dermatoses from the manufacture of plastic composite products. *Am J Contact Dermat*. 1995;6(2):95-104.
34. Ponting DJ, Ortega MA, Niklasson IB, et al. Development of new epoxy resin monomers—a delicate balance between skin allergy and polymerization properties. *Chem Res Toxicol*. 2019;32(1):57-66. doi:10.1021/acs.chemrestox.8b00169
35. O'Boyle NM, Delaine T, Luthman K, Natsch A, Karlberg AT. Analogues of the epoxy resin monomer diglycidyl ether of bisphenol F: effects on contact allergenic potency and cytotoxicity. *Chem Res Toxicol*. 2012;25(11):2469-2678. doi:10.1021/tx300305k
36. Hagvall L, Niklasson IB, Rudback J, et al. Assessment of cross-reactivity of new less sensitizing epoxy resin monomers in epoxy resin-allergic individuals. *Contact Dermatitis*. 2016;75(3):144-150. doi:10.1111/cod.12624
37. Fenske RA. Dermal exposure assessment techniques. *Ann Occup Hyg*. 1993;37(6):687-706.
38. Fenske RA. Visual scoring system for fluorescent tracer evaluation of dermal exposure to pesticides. *Bull Environ Contam Toxicol*. 1988;41(5):727-736.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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Bilag 2: Spørgeskema, informationsmateriale

Psst……

vil du være med til
at forebygge allergi?

Hej Jeg hedder Alexandra og jeg vil rigtig gerne have dig med i mit forskningsprojekt!

EPOXY VISION

Kom og få mere information
om projektet i Gæstekantinen

1. November 2019

Gul Hold: kl. 09.15-09.45

Grøn Hold: kl. 12.30-13.00

Blå Hold: kl. 21.30-22.00

Alexandra Golabek Christiansen

Læge, ph.d.- studerende

Aarhus Universitetshospital

Arbejdsmedicin

midt regionmidtjylland

Deltagerinformation om deltagelse i et videnskabeligt forsøg.

Forsøgets titel: Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering

Forespørgsel om at deltage i et videnskabeligt projekt: Vi vil spørge, om du vil deltage i et videnskabeligt forsøg, der udføres af Arbejdsmedicin, Aarhus Universitetshospital i samarbejde med din arbejdsplads. Projektet støttes af Arbejdsmiljøforskningsfonden og projektleder vil være læge og ph.d.-studerende Alexandra Golabek Christiansen. Selve projektets udførelse vil foregå i tidsperioden september 2018 og 3 år frem. Herefter vil der være en periode med analyse af indsamlet data.

Før du beslutter, om du vil deltage i forsøget, skal du fuldt ud forstå, hvad forsøget går ud på, og hvorfor vi gennemfører forsøget. Vi vil derfor bede dig om at læse denne deltagerinformation grundigt. Udover det kommende informationsmøde, er der mulighed for en supplerende samtale, hvis du har behov for det. Du er velkommen til at tage et familiemedlem eller en ven med til denne samtale. Dette vil foregå udenfor arbejdstiden.

Du har ret til betænkningstid, før du beslutter, om du vil underskrive samtykkeerklæringen. Hvis du beslutter dig for at deltage i forsøget, vil jeg til informationsmødet udlevere en samtykkeerklæring. Jeg vil bede dig om at udfylde denne indenfor 1 uge. Det er frivilligt at deltage i forsøget. Du kan når som helst og uden at give grund trække dit samtykke tilbage.

Personer med svært eksem og gravide kan ikke deltage, da lappetesten ikke kan udføres i henhold til gældende anbefalinger. Da der bruges strobelys i forbindelse med projektet, kan du ikke deltage, hvis du lider af epilepsi.

Forsøgets formål

Vi ved, at arbejde med epoxy, kan give allergi og eksem, men ofte er det svært at se, om man får epoxy på huden. Formålet med forsøget er at undersøge om man kan forebygge, at man får epoxy på huden under arbejdet ved at gøre epoxy synligt ved hjælp af ultraviolet (UV) lys. Vi vil også undersøge, om dette kan nedsætte risikoen for at udvikle epoxyallergi og eksem.

Metode og den praktiske tilrettelæggelse af forsøget

Medarbejdere, som arbejder med epoxy og kontoransatte på din virksomhed, vil blive spurgt om at deltage. Ønsker du at deltage, vil du ved start og efter 2 år blive bedt om at udfylde et spørgeskema om nuværende og tidligere udslæt på huden, astmasymptomer, øvrigt helbred, allergi og livstilsfaktorer. Spørgeskemaet besvares via et link, som vil blive sendt til din mail, hvis du ønsker at deltage.

Vi vil fra sundhedsregistre indhente oplysninger om diagnoser af hud- og luftvejssygdomme, receptpligtige lægemidler til behandling af sygdomme i huden og luftvejene, uddannelse og arbejdsmarkedstilknytning. Undersøgelsen er ikke anonym, men alle oplysninger behandles strengt fortroligt, og kun forskerne bag undersøgelsen vil få adgang til oplysningerne.

Hvis du i spørgeskemaet fortæller, at du har hududslæt eller luftvejssymptomer, tilbydes du en lægeundersøgelse. Har du hududslæt vil vi gerne tage billeder af din hud.

Epoxyen der benyttes på din virksomhed bliver synligt, når det belyses med UV-lys. Derfor vil vi undersøge din hud i en kabine, som kan registrere, om du har fået epoxy på huden. Dette sker hver gang, du forlader et arbejdsområde med epoxy.

Da det er et videnskabeligt forsøg, vil halvdelen af deltagerne ikke få mulighed for at se den selvlysende epoxy på huden. Det afgøres ved lodtrækning, hvilken af de to grupper man kommer i. Registreringerne i kabinen vil foregå dagligt over 1-2 måneder, 4 gange på et år.

Vi vil 1-2 gange i løbet af projektperioden bede dig om at få lavet en lappetestet for hudallergi overfor epoxy og enkelte andre kemikalier. Prøverne sættes fast på ryggen med plaster, hvor de sidder i 2 dage. Prøverne aflæses efter 4 og 6 dage for en allergisk reaktion. Dette vil vise sig som en rød, kløende plet. Påsætning og aflæsning af lappeprøverne vil foregå i arbejdstiden. Hvis der kommer en reaktion efter dag 6, vil vi bede dig om at tage et billede af din ryg samt underrette os via mail. Der er nogle forholdsregler i forbindelse med lappetestningen, som du skal kende til:

- Undgå sol og solarium på ryggen fra 14 dage inden testen og til testen er slut
- Undlad at bruge hormoncreme på ryggen fra 3 dage inden testen og til testen er slut. Hvis man er i behandling med hormoncreme, må man gerne behandle den øvrige del af kroppen i testperioden
- Brug ikke fugtighedscreme på ryggen fra dagen før testen og til testen er slut. Resten af kroppen må gerne behandles med fugtighedscreme
- Det er en god idé at tage en gammel bluse eller undertrøje på, mens testen foregår. Prøverne er blandt med vaseline og kan indeholde farvestoffer, der kan smitte af. De steder, prøverne har siddet, tegnes op med tusch, som kan smitte af på tøj og sengetøj
- Undgå at få vand på ryggen i testperioden
- Undgå at kradse på ryggen under testningen, da det kan gøre det svært at aflæse evt. reaktioner på testen
- Hvis man har meget eksem på ryggen, kan det i nogle tilfælde blive nødvendigt at udsætte testen
- Ved meget hårvækst på ryggen kan det blive nødvendigt at barbere området, hvor lappetesten skal placeres.

Du vil blive informeret om undersøgelsesresultaterne, med mindre du frabeder dig disse oplysninger på samtykkeerklæringen.

Vi vil løbende udsende informationer omkring projektet.

Forsøgets risici:

I forbindelse med lappetestning kan der forekomme lette bivirkninger i form af irritation af huden og opblussen i et eventuelt eksem. En sjælden gang kan der komme ændring i hudens pigment, så der kommer små områder med lidt mørkere hudfarve. Disse forandringer forsvinder som regel af sig selv igen.

I sjældne tilfælde kan lappetesten medføre allergi overfor stofferne i testen. Risikoen for dette er mindre end 1 % og lappetest overfor epoxy er et godkendt lægemiddel, som 20.000 mennesker testes med årligt i Danmark.

I Arbejdstilsynets bekendtgørelse nr. 1793 af 18. december 2015 fremgår, at personer, der har eksem eller epoxyallergi, ikke må arbejde med epoxy. Resultaterne af lappetestene er personlige og vil blive behandlet fortroligt ligesom alle øvrige undersøgelsesresultater og vil ikke blive videregivet til Arbejdstilsynet, virksomheden eller andre. Deltagere, som rapporterer hududslæt eller luftvejssymptomer eller slår ud ved lappetesten, tilbydes arbejdsmedicinsk undersøgelse og rådgivning.

Bivirkninger i forbindelse med blodprøvetagningen er beskedne. Det drejer sig om smerte i forbindelse med stikket og risikoen for et blåt mærke, hvilket forsvinder efter et par dage.

Undersøgelse af huden med UV-belysning vil overholde Arbejdstilsynets grænseværdier.

Der kan være risici ved forsøget, som vi endnu ikke kender. Vi beder dig derfor om at fortælle, hvis du oplever problemer med dit helbred, mens forsøget står på. Hvis vi opdager bivirkninger, som vi ikke allerede har fortalt dig om, vil du naturligvis blive orienteret med det samme, og du vil skulle tage stilling til, om du ønsker at fortsætte i forsøget.

Udtagning af biologisk materiale fra forsøgspersoner

I løbet af projektperioden vil du blive bedt om at afgive en blodprøve på ca. 20 ml til undersøgelse for allergi og forekomst af epoxy komponenter, som tages i albuebøjningen. Efter analyse vil prøverne blive kasseret, senest i 2031. Du kan også være med i undersøgelsen uden at få taget en blodprøve.

Forsøgets nytte

Vi håber, at synliggørelse af epoxy med UV-lys kan forebygge allergi og eksem for de mange, som arbejder med epoxy. Ved at deltage i forsøget vil du blive tilbudt undersøgelse og rådgivning omkring din hudsygdom. Kontoransatte inviteres til at deltage i en kontrolgruppe, som ikke arbejder med epoxy.

Hvis forsøget må afbrydes

Vi mener ikke, der er forhold, der fører til, at man bliver taget ud af forsøget, eller at det afbrydes.

Vederlag

Du vil ikke modtage vederlag for din deltagelse. Undersøgelser og lappetests vil foregå i arbejdstiden og forsøgsdeltagelsen vil ikke være forbundet med tabt arbejdsfortjeneste.

Økonomi

Forsøget udgår fra Arbejdsmedicin, Aarhus Universitetshospital og Arbejdsmiljøforskningsfonden støtter projektet med 3,4 millioner kroner. Støtten omfatter udgifter til materialer (lappetest, blodprøver, formidling) og lønudgifter. Projektet støttes af din virksomhed, som også bidrager økonomisk til udvikling af udstyr samt stiller personale til rådighed. Der søges aktuelt yderligere økonomisk støtte til projektet

Kontaktpersoner

Forsøgsansvarlig:

Henrik Kolstad
Professor, overlæge
Arbejdsmedicin, Aarhus Universitetshospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N

Kontaktperson:
Alexandra Golabek Christiansen
PhD studerende, læge
Arbejdsmedicin, Aarhus Universitetshospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N
E-mail: Alexpe@rm.dk
Tlf: 61369475

Vi håber, at du med denne information har fået tilstrækkeligt indblik i, hvad det vil sige at deltage i forsøget, og at du føler dig rustet til at tage beslutningen om din eventuelle deltagelse. Vi beder dig også om at læse det vedlagte materiale "Forsøgspersoners rettigheder i et sundhedsvidenskabeligt forskningsprojekt" og "Før du beslutter dig". Hvis du vil vide mere om forsøget, er du meget velkommen til at kontakte læge Alexandra Golabek Christiansen.

Med venlig hilsen

Alexandra Golabek Christiansen

Deltagerinformation om deltagelse i et videnskabeligt forsøg.

Forsøgets titel: Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering

Forespørgsel om at deltage i et videnskabeligt projekt: Tak for dit tilsagn om at deltage som kontrolperson i Epoxy-Vision projektet.

Projektleder er læge og ph.d.-studerende Alexandra Golabek Christiansen fra Arbejdsmedicin, Aarhus Universitetshospital. Selve projektets udførelse foregår i tidsperioden september 2018 og ca. 4 år frem. Herefter vil der være en periode med analyse af indsamlet data.

Før du beslutter, om du vil deltage i forsøget, skal du fuldt ud forstå, hvad forsøget går ud på, og hvorfor vi gennemfører forsøget. Vi vil derfor bede dig om at læse denne deltagerinformation grundigt.

Forsøgets formål

Vi ved, at arbejde med epoxy, kan give allergi og eksem, men ofte er det svært at se, om man får epoxy på huden. Formålet med forsøget er at undersøge om man kan forebygge, at man får epoxy på huden under arbejdet ved at gøre epoxy synligt ved hjælp af ultraviolet (UV) lys. Vi vil også undersøge, om dette kan nedsætte risikoen for at udvikle epoxyallergi og eksem.

Metode og den praktiske tilrettelæggelse af forsøget

Epoxyen der benyttes på din virksomhed bliver synligt, når det belyses med UV-lys. Medarbejdere, der arbejder med produktet, vil få undersøgt huden i en boks, som kan registrere, om de har fået epoxy på huden. Dette sker hver gang, de forlader et arbejdsområde med epoxy.

Vi ønsker at teste både medarbejdere, der arbejder med epoxy og medarbejdere, der ikke gør, med en lappetest. Lappetesten sættes fast på ryggen med plaster, hvor prøverne sidder i 2 dage. Prøverne aflæses efter 4 og 6 dage for en allergisk reaktion. Dette vil vise sig som en rød, kløende plet. Påsætning og aflæsning af lappeprøverne vil foregå i arbejdstiden. Hvis der kommer en reaktion efter dag 6, vil vi bede dig om at tage et billede af din ryg samt underrette os på mail. Der er nogle forholdsregler i forbindelse med lappetestningen, som du skal kende til:

- Undgå sol og solarium på ryggen fra 14 dage inden testen og til testen er slut
- Undlad at bruge hormoncreme på ryggen fra 3 dage inden testen og til testen er slut. Hvis man er i behandling med hormoncreme, må man gerne behandle den øvrige del af kroppen i testperioden
- Brug ikke fugtighedscreme på ryggen fra dagen før testen og til testen er slut. Resten af kroppen må gerne behandles med fugtighedscreme
- Det er en god idé at tage en gammel bluse eller undertrøje på, mens testen foregår. Prøverne er blandt med vaseline, og kan indeholde farvestoffer, der kan smitte af. De steder, prøverne har siddet, tegnes op med tusch , som kan smitte af på tøj og sengetøj
- Undgå at få vand på ryggen i testperioden
- Undgå at kradse på ryggen under testningen, da det kan gøre det svært at aflæse evt. reaktioner på testen

- Hvis man har meget eksem på ryggen, kan det i nogle tilfælde blive nødvendigt at udsætte testen
- Ved meget hårvækst på ryggen kan det blive nødvendigt at barbere området, hvor lappetesten skal placeres.

Personer med svært eksem og gravide kan ikke deltage, da lappetesten ikke kan udføres i henhold til gældende anbefalinger.

Du vil blive informeret om undersøgelsesresultaterne, med mindre du frabeder dig disse oplysninger på samtykkeerklæringen.

Vi vil fra sundhedsregistre indhente oplysninger om diagnoser af hud- og luftvejssygdomme, receptpligtige lægemidler til behandling af sygdomme i huden og luftvejene, uddannelse og arbejdsmarkedstilknytning. Undersøgelsen er ikke anonym, men alle oplysninger behandles strengt fortroligt, og kun forskerne bag undersøgelsen vil få adgang til oplysningerne.

Udtagning af biologisk materiale fra forsøgspersoner

Blodprøven, som tages, er på ca. 20 ml. Den tages i albuebøjningen og undersøges for allergi og forekomst af epoxy komponenter. Efter analyse vil prøverne blive kasseret, senest i 2031. Du kan også være med i undersøgelsen uden at få taget en blodprøve.

Forsøgets risici:

I forbindelse med lappetestning kan der forekomme lette bivirkninger i form af irritation af huden og opblussen i et eventuelt eksem. En sjælden gang kan der komme ændring i hudens pigment, så der kommer små områder med lidt mørkere hudfarve. Disse forandringer forsvinder som regel af sig selv igen.

I sjældne tilfælde kan lappetesten medføre allergi overfor stofferne i testen. Risikoen for dette er mindre end 1 % og lappetest overfor epoxy er et godkendt lægemiddel, som 20.000 mennesker testes med årligt i Danmark.

I Arbejdstilsynets bekendtgørelse nr. 1793 af 18. december 2015 fremgår, at personer, der har eksem eller epoxyallergi ikke må arbejde med epoxy. Resultaterne af lappetestene er personlige og vil blive behandlet fortroligt ligesom alle øvrige undersøgelsesresultater og vil ikke blive videregivet til Arbejdstilsynet, virksomheden eller andre.

Bivirkninger i forbindelse med blodprøvetagningen er beskedne. Det drejer sig om smerte i forbindelse med stikket og risikoen for et blåt mærke, hvilket forsvinder efter et par dage.

Der kan være risici ved forsøget, som vi endnu ikke kender. Vi beder dig derfor om at fortælle, hvis du oplever problemer med dit helbred, mens forsøget står på. Hvis vi opdager bivirkninger, som vi ikke allerede har fortalt dig om, vil du naturligvis blive orienteret med det samme, og du vil skulle tage stilling til, om du ønsker at fortsætte i forsøget.

Forsøgets nytte

Vi håber, at synliggørelse af epoxy med et selvlysende tilsætningsstof kan forebygge allergi og eksem for de mange, som arbejder med epoxy.

Hvis forsøget må afbrydes

Vi mener ikke der er forhold der fører til, at man bliver taget ud af forsøget, eller at det afbrydes.

Vederlag

Undersøgelser og lappetests vil foregå i arbejdstiden og forsøgsdeltagelsen vil ikke være forbundet med tabt arbejdsfortjeneste.

Økonomi

Forsøget udgår fra Arbejdsmedicin, Aarhus Universitetshospital og Arbejdsmiljøforskningsfonden støtter projektet med 3,4 millioner kroner. Støtten omfatter udgifter til materialer (lappetest, blodprøver, formidling) og lønudgifter. Projektet støttes af din virksomhed, som også bidrager økonomisk til udvikling af udstyr samt stiller personale til rådighed. Der søges aktuelt yderligere økonomisk støtte til projektet

Kontaktpersoner

Forsøgsansvarlig:
Henrik Kolstad
Professor, overlæge
Arbejdsmedicin, Aarhus Universitetshospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus

Kontaktperson:
Alexandra Golabek Christiansen
PhD studerende, læge
Arbejdsmedicin, Aarhus Universitetshospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus
E-mail: Alexpe@rm.dk
Tlf: 61369475

Vi håber, at du med denne information har fået tilstrækkeligt indblik i, hvad det vil sige at deltage i forsøget, og at du føler dig rustet til at tage beslutningen om din eventuelle deltagelse. Vi beder dig også om at læse det vedlagte materiale "Forsøgspersoners rettigheder i et sundhedsvidenskabeligt forskningsprojekt" og "Før du beslutter dig". Hvis du vil vide mere om forsøget, er du meget velkommen til at kontakte Alexandra Golabek Christiansen.

Med venlig hilsen

EPOXY VISION

Alexandra Golabek Christiansen

Informeret samtykke til deltagelse i et sundhedsvidenskabeligt forskningsprojekt.

Forskningsprojektets titel: Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering

Erklæring fra forsøgspersonen:

Jeg har fået skriftlig og mundtlig information og jeg ved nok om formål, metode, fordele og ulemper til at sige ja til at deltage.

Jeg ved, at det er frivilligt at deltage, og at jeg altid kan trække mit samtykke tilbage uden at miste mine nuværende eller fremtidige rettigheder til behandling.

Jeg giver samtykke til, at deltage i forskningsprojektet og til, at en blodprøve udtages med henblik på opbevaring i en forskningsbiobank. Jeg har fået en kopi af dette samtykkeark samt en kopi af den skriftlige information om projektet til eget brug.

Forsøgspersonens navn:_____

Cpr-nummer:_____ _____

Mail:_____

Telefonnummer:_____

Ved at angive kontakt oplysninger gives samtidig tilladelse til, at vi må kontakte dig.

Dato: _____ Underskrift: _____

Hvis der kommer nye væsentlige helbredsoplysninger frem om dig i forskningsprojektet vil du blive informeret. Vil du **frabede** dig information om nye væsentlige helbredsoplysninger, som kommer frem i forskningsprojektet, bedes du markere her: _____ (sæt x)

Ønsker du at blive informeret om forskningsprojektets resultat samt eventuelle konsekvenser for dig?:

Ja _____ (sæt x) Nej _____ (sæt x)

Erklæring fra den, der afgiver information:

Jeg erklærer, at forsøgspersonen har modtaget mundtlig og skriftlig information om forsøget.

Efter min overbevisning er der givet tilstrækkelig information til, at der kan træffes beslutning om deltagelse i forsøget.

Navnet på den, der har afgivet information:

Dato: _____ Underskrift: _____

Epoxy vision – Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering

"Epoxy vision" er et videnskabeligt projekt, der udføres af Arbejdsmedicin, Aarhus Universitetshospital.

Arbejde med epoxy kan give allergi og eksem, men det er ofte svært at se, om man får epoxy på huden. Formålet med forsøget er at undersøge, om man kan undgå at få epoxy på huden ved at gøre epoxy synligt ved hjælp af ultraviolet (UV) lys. Vi vil undersøge, om dette kan nedsætte risikoen for at udvikle eksem og allergi.

Ca. 300 ansatte på Siemens og Vestas, som arbejder med epoxy, er blevet inviteret til at deltage i projektet. De er blevet bedt om at svare på et spørgeskema, få udført en lappetest på huden for epoxy allergi og få taget en blodprøve (der viser allergi overfor bl.a. hund, kat, pollen og hvis muligt, epoxy i blodet) Indtil videre har vi testet ca. 160 medarbejdere på Siemens.

Det er nødvendigt med en kontrolgruppe, som ikke dagligt er i direkte kontakt med epoxy. Derfor inviterer vi kontoransatte fra Siemens og Vestas til at deltage i Epoxy vision projektet.

Det indebærer at man skal svare på et spørgeskema, få udført en lappetest og få taget en blodprøve. Man kan nøjes med at svare på spørgeskemaet og stadig bidrage til undersøgelsen.

Link til spørgeskemaet finder du her: https://redcap.au.dk/surveys/?s=JWDHTFH778

En lappetest viser, om man har hudallergi overfor bestemte stoffer. Du vil blive testet med 35 hyppige allergifremkaldende stoffer (nikkel, parfume, konserveringsmidler i sæbe og kosmetik, gummikemikalier mm.). Derudover tester vi med de epoxyprodukter, der bruges i produktionen på din virksomhed.

Lappetesten sættes på ryggen med plaster. Den skal sidde på i 48 timer, hvorefter du selv tager den af. Efter 4 og 6 dage aflæser vi resultatet på din ryg og ser, om der er kommet en allergisk reaktion. I hele testperioden (7 dage) må der ikke komme vand på ryggen.

Blodprøven tages på dag 4 og du vil få svar via mail.

I spørgeskemaet kan du angive om du er interesseret i at deltage med lappetest og blodprøve.

De som ønsker dette, vil få yderligere informationer. Udfyldelse af spørgeskema, lappetest og blodprøve foregår på din arbejdsplads i arbejdstiden. Anlæggelse og aflæsning af lappetest samt blodprøve foregår over 3 dage det vil tage ca. 15 minutter pr. gang. **Undersøgelserne vil finde sted i uge 43, 44 og 45.**

Det er vigtigt for undersøgelsens kvalitet at mange deltager, og jeg håber meget, at du vil deltage.

Du er velkommen til at kontakte mig på nedenstående telefon og mail.

Deadline for besvarelse er mandag d. 7/10 2019

Med venlig hilsen
Alexandra Golabek Christiansen
PhD studerende, læge
Arbejdsmedicin, Aarhus Universitetshospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N
E-mail: Alexpe@rm.dk Tlf: 61369475

Epoxy vision – Synligt og sikkert arbejde med epoxy: Forebyggelse af eksem med visualisering

"Epoxy vision" er et videnskabeligt projekt, der udføres af Arbejdsmedicin, Aarhus Universitetshospital.

Arbejde med epoxy kan give allergi og eksem, men det er ofte svært at se, om man får epoxy på huden. Formålet med forsøget er at undersøge, om man kan undgå at få epoxy på huden ved at gøre epoxy synligt ved hjælp af ultraviolet (UV) lys. Vi vil undersøge, om dette kan nedsætte risikoen for at udvikle eksem og allergi.

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Blodprøven tages på dag 4 og du vil få svar via mail.

I spørgeskemaet kan du angive om du er interesseret i at deltage med lappetest og blodprøve.

De som ønsker dette, vil få yderligere informationer. Udfyldelse af spørgeskema, lappetest og blodprøve foregår på din arbejdsplads i arbejdstiden. Anlæggelse og aflæsning af lappetest samt blodprøve foregår over 3 dage det vil tage ca. 15 minutter pr. gang. **Undersøgelserne vil finde sted i december 2019 samt januar/februar 2020**

Det er vigtigt for undersøgelsens kvalitet at mange deltager, og jeg håber meget, at du vil deltage.

Du er velkommen til at kontakte mig på nedenstående telefon og mail.

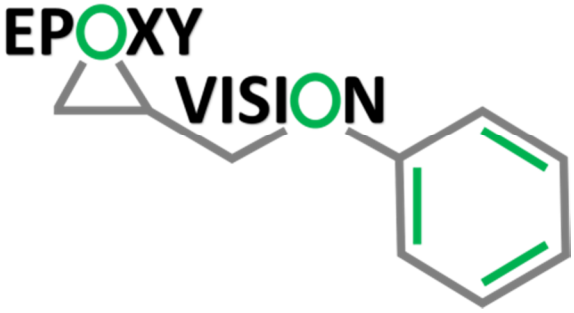
Deadline for besvarelse er fredag d. 11/10 2019

Med venlig hilsen
Alexandra Golabek Christiansen
PhD studerende, læge
Arbejdsmedicin, Aarhus Universitetshospital, Palle Juul-Jensens Boulevard 99, 8200 Aarhus N
E-mail: Alexpe@rm.dk Tlf: 61369475

AARHUS UNIVERSITET

Spørgeskema

Forskningsprojektet:
Synligt og sikkert arbejde med epoxy



AALBORG UNIVERSITETSHOSPITAL
– i gode hænder

midt regionmidtjylland

Det Nationale Forskningscenter for Arbejdsmiljø

Vejledning

Du modtager dette spørgeskema, som led i projektet: Synligt og sikkert arbejde med epoxy. Du har modtaget både mundtlig og skriftlig information om projektet.

De fleste vil bruge ca. 5-7 minutter på at udfylde skemaet.

Det udfyldte spørgeskema lægges enten i de opsatte postkasser på din arbejdsplads eller lægges i vedlagte frankerede kuvert og sendes retur med posten.

Du vil sikkert komme i tvivl ved nogle af spørgsmålene, men det er vigtigt, at du svarer så godt du kan, og at alle spørgsmålene besvares.

Hvis du har spørgsmål til spørgeskemaet, er du velkommen til at kontakte undertegnede læge, Alexandra Golabek Christiansen på tlf. 61 36 94 75 (hverdage kl. 9-14) eller på e-mail: Alexpe@rm.dk

Sådan udfylder du spørgeskemaet

Brug venligst sort eller blå kuglepen. Sæt X og skriv tal så de er nemme at tolke, som vist i eksemplet nedenfor.

Sæt tydelige X	Nej ☒ Ja ☐
Hvis et felt er **udfyldt forkert**, skraveres den pågældende kasse, og krydset sættes det rigtige sted	Nej ☒ Ja ☒
Hvis der er et ekstra spørgsmål, efter det svar du vælger, skal du skrive dit svar (eller tal) på linjen	Ja ☒ Hvornår? 1997 *(årstal)*
Besvar spørgsmålene i rækkefølge, med mindre der står noget andet efter det svar, du vælger. Hvis der står *(gå til spørgsmål…)*, skal du gå direkte til det angivne spørgsmål uden at svare på spørgsmålene imellem, fx	Ja ☒ *(gå til spørgsmål 5)*

Med venlig hilsen

Alexandra Golabek Christiansen, Læge, ph.d.- studerende

Arbejdsmedicin
Aarhus Universitetshospital

Hudsymptomer

1. Har du nogensinde haft <u>håndeksem</u>?

Nej	☐	
Ja	☐	

2. Har du nogensinde haft <u>eksem på håndled eller underarme</u> (bortset fra albuebøjningerne)?

Nej	☐	*Hvis du også svarede "nej" til spørgsmål 1, gå til spørgsmål 5*
Ja	☐	

3. Hvornår havde du sidst eksem på hænder, håndled eller underarme? *(højst ét svar i hver kolonne)*

	Håndeksem	Eksem på håndled/underarme
Jeg har det i øjeblikket	☐	☐
Ikke i øjeblikket, men inden for de sidste 3 måneder	☐	☐
Mellem 3-12 måneder siden	☐	☐
Mere end 12 måneder siden	☐	☐
Hvilket år var sidste gang? *(giv dit bedste skøn)*	_____(årstal)	_____(årstal)

4. Bedres dit eksem, når du holder fri fra dit sædvanlige arbejde (f.eks. weekender, ferier eller længere perioder)? *(højst ét svar i hver kolonne)*

	Håndeksem	Eksem på håndled/underarme
Nej	☐	☐
Ja, undertiden	☐	☐
Ja, som regel	☐	☐
Ved ikke	☐	☐

5. Har du nogensinde haft børneeksem? *(kaldes også astmaeksem eller atopisk eksem)*

Nej	☐			
Ja	☐	**Er det konstateret af læge?**	Nej ☐	
			Ja ☐	**Hvornår?**_____ (årstal)
Ved ikke	☐			

6. Lider du af allergi påvist ved lappetest/plasterprøve ved hudlæge?

Nej	☐
Ja	☐
Hvilke allergier:_____	

Luftvejssymptomer

7. Har du haft pibende eller hvæsende vejrtrækning på noget tidspunkt inden for *de seneste 12 måneder?*

Nej	☐	*Hvis "nej", gå til spørgsmål 9*
Ja	☐	

8. Havde du pibende eller hvæsende vejrtrækning uden at være forkølet?

Nej	☐
Ja	☐

9. Er du vågnet med en fornemmelse af trykken for brystet på noget tidspunkt inden for *de seneste 12 måneder?*

Nej	☐
Ja	☐

10. Er du blevet vækket af et anfald af åndenød på noget tidspunkt inden for *de seneste 12 måneder?*

Nej	☐
Ja	☐

11. Er du blevet vækket af et hosteanfald på noget tidspunkt inden for *de seneste 12 måneder?*

Nej	☐
Ja	☐

12. Har du haft et astmaanfald inden for *de seneste 12 måneder?*

Nej	☐
Ja	☐

13. Bruger du i øjeblikket medicin mod astma (f.eks. inhalator, spray eller piller)?

Nej	☐
Ja	☐

14. Har du allergi i næsen (f.eks. høfeber)?

Nej	☐
Ja	☐

15. Har du eller har du haft astma?

Nej	☐	*Hvis "nej", gå til spørgsmål 18*
Ja	☐	

16. Har en læge nogensinde fortalt dig, at du har eller har haft astma?

Nej	☐
Ja	☐

17. Hvor gammel var du, da du havde dit første astmaanfald? _____(år)

18. Har du før din nuværende ansættelse arbejdet med epoxyprodukter?

Nej	☐
Ja	☐

19. Ryger du? *(det gælder også, hvis du kun ryger enkelte cigaretter/cigarer eller pibe om ugen)*

Ja	☐
Aldrig	☐
Tidligere	☐

Eventuelle kommentarer: _____

EPOXY VISION

Starter 2. december på Ultimo 4

Information

Kære 3B medarbejdere.
Først og fremmest en stor tak til alle som har valgt at deltage i Epoxy-Vision. I er med til at højne sikkerheden for jer selv og jeres kollegaer i forbindelse med arbejde med epoxy-resin.

Første skridt

Første skridt starter på U4 d. 2. december.
Der vil blive lagt lappetest og udtaget blodprøve.
Læge Alexandra Christiansen og bioanalytiker Karen Just kommer til at sidde i 2 skurvogne udenfor hal 10

Tilmelding

Tilmelding vil fortsat være muligt for alle 3B medarbejdere. Hvis nogen har mistet sin konvolut med tilmelding eller ikke har fået muligheden for at tilmelde sig, giv da besked til din GL'er eller ring til intern projektleder Marcus Illanes på 24295553

Standardsvar på blodprøver

Kære deltager

I forbindelse med din deltagelse i Epoxy-Vision projektet har du fået taget en blodprøve.

Din blodprøve var **normal** og det tyder ikke på at du har allergi overfor husstøvmide, kat, hund, græs, birk, gråbynke, hest eller skimmel.

Har du spørgsmål, må du endelig kontakte mig.

Med venlig hilsen

Alexandra

Kære deltager

I forbindelse med din deltagelse i Epoxy-Vision projektet har du fået taget en blodprøve.

Din blodprøve tyder på, at du har allergi overfor husstøvmide, kat, hund, græs, birk, gråbynke, hest **eller** skimmel.
Hvis du døjer med høfeber, astma eller øjenkløe, kan det være en god ide at gå til din læge og få taget en blodprøve, der kan vise hvilken allergi, du har.

Har du spørgsmål, må du endelig kontakte mig.

Med venlig hilsen

Alexandra

EPOXYVISION

STARTEN
Projektet løb af stablen d. 2/12 2018 og ved udgangen af januar 2019 vil 100 deltagere fra 3B være lappetestet. Planen er at UV-delen af projektet starter op i april.
Medarbejdere fra 3C har vist interesse for projektet og i løbet af februar, vil der blive åbnet op for deltagelse fra 3C.
I februar måned rykker vi til Lem, hvor vi vil påbegynde lappetestning af deltagere fra Vestas. Vi regner med, at der her vil blive testet ca. 100 medarbejdere.

RESULTATER OG BLODPRØVER
Billeder, spørgeskemabesvarelser, resultater af lappetest og blodprøver opbevares på Region Midtjyllands og Aarhus Universitets servere, hvor kun forskerne i dette projekt har adgang.
Alle oplysninger bliver behandlet strengt fortroligt efter persondataloven.
Blodprøverne opbevares i en fryser på Aarhus Universitetshospital. I løbet af foråret, vil de blive analyseret for allergi overfor kat, hund, birk, græs, grå bynke og husstøvmider. Alle deltagere modtager svar efterfølgende. En lille del af blodet opbevares for at kunne måle epoxy i blodet.

Vi er enormt glade for den positive stemning og tilliden vi har mødt på Siemens. Det er en fornøjelse at så mange medarbejdere, er med i projektet. Der har været super opbakning fra alle deltagere samt GL'er og TL'er. Alle har ydet en stor indsats med koordinering og fremmøde. En stor tak for det!
Vi håber på fortsat godt samarbejde i den næste del af projektet.

Med venlig hilsen

Alexandra

EPOXY VISION

"Jeg støtter 100% op om dette projekt. Vi får her en helt fantastisk mulighed for at se hvordan vi undgår spredning af epoxy udenfor de områder vi bruger epoxy. At jeg samtidig får tilbudt en mulighed for at få en stor allergitest, gør det kun endnu bedre at deltage i projektet."

Finn Brandborg Sørensen

EPOXY VISION

Sidste skift

Vi er nu nået til de sidste 2 skift: Ultimo 2 og Primo 2. De to skift vil få lagt lappetest og udtaget blodprøve i løbet af januar.
Derefter er planen fortsat, at UW-boxen og den selvlysende resin kommer op i produktionen i løbet af marts/april.

Tilmelding

Tilmelding vil fortsat være muligt for alle 3B medarbejdere. Hvis nogen har mistet sin konvolut med tilmelding eller ikke har fået muligheden for at tilmelde sig, giv da besked til din GL'er eller ring til intern projektleder Marcus Illanes på 24295553

Follow-up mail

Kære deltager i Epoxy-Vision

For snart 2 år siden stod Karen og jeg i skurvognen ved Siemens og lappetestede. Vi glædes stadig over jeres fantastiske modtagelse af os og projektet. Vi er stolte over, at det lykkedes os at teste 160 medarbejdere.

Til trods for, at der er gået en del tid med at få kabinen køreklar, er jeg meget glad for den store tilslutning til brugen og takker for jeres tålmodighed.

Det er nu tid til, at vi gerne vil lappeteste dig igen, så vi kan se, om der er sket en ændring siden sidst. Jeg ved, at lappetesten for nogen kan være generende, men jeg håber stadig, at du kan overtales til endnu engang at blive testet.

Hvis du ikke er ansat på Siemens længere, kan du stadig blive lappetestet på Arbejdsmedicinsk afdeling på Aalborg eller Aarhus Universitetshospital.

Nedenfor er der et link til et spørgeskema. Jeg håber, du vil bruge tid på endnu engang at besvare det - også selvom du ikke vil lappetestes igen.
I spørgeskemaet vil du blive spurgt, om du vil lappetestes. Svarer du ja, vil jeg kontakte dig, så vi kan aftale tidspunkt for testen.

Med venlig hilsen

Alexandra Golabek Christiansen

EPOXY VISION PROJEKTET

HVAD VED VI

- Epoxy komponenter kan forårsage hudallergi (sensibilisering) og eksem
- En høj forekomst af hudallergi og eksem er tidligere beskrevet blandt medarbejdere i vindmølleindustrien
- Omfattende brug af værnemidler er påkrævet ved brug af epoxy komponenter

FORMÅL

Projektet blev i januar 2018 bevilget 3.400.000 fra Arbejdsmiljøforskningsfonden. Projektets overordnede formål er at forebygge eksem forårsaget af arbejde med epoxy. Første del af studiet var at undersøge forekomsten af hudallergi og eksem blandt medarbejdere i vindmølleindustrien, der benytter de nuværende anbefalede værnemidler.

HVAD HAR VI GJORT

182 produktionsmedarbejdere og 41 kontormedarbejdere på Siemens Gamesa og Vestas Wind Systems A/S har besvaret et spørgeskema, fået undersøgt deres hud og er blevet lappetestet med epoxy komponenter benyttet på virksomhederne.

HVAD HAR VI FUNDET UD AF

- 9% af produktionsmedarbejderne (16 ud af 182) og ingen kontormedarbejdere havde hudallergi over for epoxy.
- Hudallergi var hyppigst blandt folk ansat < 1 år.
- Blandt deltagere uden børneeksem var risikoen for eksem højere blandt produktionsmedarbejdere sammenlignet med kontormedarbejderne.
- Medarbejdere fra spartling havde den højeste risiko for hudallergi og eksem.
- Hudallergi var associeret med forekomst af eksem.
- Alle, der reagerede på epoxy på lappetesten, reagerede overfor resinerne DGEBA-R og DGEBF-R. 1 ud af 4 der havde en reaktion på epoxy resiner fra produktionen, reagerede ikke på standard lappeseriens epoxy.

Artiklen: " Prevalence of skin sensitisation and dermatitis among epoxy-exposed workers in the wind turbine industry" vil blive udgivet i et videnskabeligt tidsskrift

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NÆSTE SKRIDT

Vi arbejder fortsat videre med Epoxy Vision kabinen, som har til formål at gøre epoxy selvlysende ved UV-belysning, så man kan se om man har fået epoxy på huden. Denne del af projektet har været ramt af tekniske udfordringer og Covid-19, men vi håber stadig, at gennemføre afprøvningen af kabinen i løbet af næste år.

KONTAKT

Alexandra Golabek Christiansen, læge, Arbejdsmedicin, Aarhus Universitetshospital
mail: Alexpe@rm.dk, tlf: 78450900

Referencer

1. Prodi A, Rui F, Fortina AB, Corradin MT, Filon FL. Occupational sensitization to epoxy resins in Northeastern Italy (1996-2010). International journal of occupational and environmental health. 2015;21(1):82-7.
2. Cao LY, Sood A, Taylor JS. Hand/face/neck localized pattern: sticky problems--resins. Dermatologic clinics. 2009;27(3):227-49, v.
3. Pham HQ, Marks MJ. Epoxy Resins. Ullmann´s Encyclopedia of Industrial Chemistry. 2005.
4. Menne T, Johansen JD, Sommerlund M, Veien NK, Danish Contact Dermatitis G. Hand eczema guidelines based on the Danish guidelines for the diagnosis and treatment of hand eczema. Contact dermatitis. 2011;65(1):3-12.
5. Nguyen V, Simon L, Jaqua E. Allergic Dermatoses. Primary care. 2016;43(3):433-49.
6. Johansen JD, Aalto-Korte K, Agner T, Andersen KE, Bircher A, Bruze M, et al. European Society of Contact Dermatitis guideline for diagnostic patch testing - recommendations on best practice. Contact dermatitis. 2015;73(4):195-221.
7. Mowad CM. Patch testing: pitfalls and performance. Current opinion in allergy and clinical immunology. 2006;6(5):340-4.
8. Romyhr O, Nyfors A, Leira HL, Smedbold HT. Allergic contact dermatitis caused by epoxy resin systems in industrial painters. Contact dermatitis. 2006;55(3):167-72.
9. Ponten A, Carstensen O, Rasmussen K, Gruvberger B, Isaksson M, Bruze M. Epoxy-based production of wind turbine rotor blades: occupational contact allergies. Dermatitis : contact, atopic, occupational, drug. 2004;15(1):33-40.
10. Aalto-Korte K, Pesonen M, Suuronen K. Occupational allergic contact dermatitis caused by epoxy chemicals: occupations, sensitizing products, and diagnosis. Contact dermatitis. 2015;73(6):336-42.
11. Aalto-Korte K, Suuronen K, Kuuliala O, Henriks-Eckerman ML, Jolanki R. Contact allergy to epoxy hardeners. Contact dermatitis. 2014;71(3):145-53.
12. Geier J, Lessmann H, Hillen U, Jappe U, Dickel H, Koch P, et al. An attempt to improve diagnostics of contact allergy due to epoxy resin systems. First results of the multicentre study EPOX 2002. Contact dermatitis. 2004;51(5-6):263-72.
13. Geier J, Lessmann H, Hillen U, Skudlik C, Jappe U. Sensitization to reactive diluents and hardeners in epoxy resin systems. IVDK data 2002-2011. Part I: reaction frequencies. Contact dermatitis. 2016;74(2):83-93.
14. Holness LD, Nethercott JR. Results of testing with epoxy resin in an occupational health clinic population. American Journal of contact dermatitis. 1992;3(4):169-74.
15. Caroe TK, Ebbehoj N, Agner T. A survey of exposures related to recognized occupational contact dermatitis in Denmark in 2010. Contact dermatitis. 2014;70(1):56-62.
16. Ponten A, Carstensen O, Rasmussen K, Gruvberger B, Isaksson M, Bruze M. Epoxy-based production of wind turbine rotor blades: occupational dermatoses. Contact dermatitis. 2004;50(6):329-38.
17. Rasmussen K, Carstensen O, Pontén A, Gruvberger B, Isaksson M, Bruze M. Risk of contact allergy and dermatitis at a wind turbine plant using epoxy resin-based plastics. International archives of occupational and environmental health. 2005;78(3):211-7.
18. Nielsen NH, Menne T. Allergic contact sensitization in an unselected Danish population. The Glostrup Allergy Study, Denmark. Acta Dermato-Venereologica. 1992;72(6):456-60.
19. Fenske RA, Leffingwell JT, Spear RC. A video imaging technique for assessing dermal exposure. I. Instrument design and testing. American Industrial Hygiene Association Journal. 1986;47(12):764-70.

20. Fenske RA, Wong SM, Leffingwell JT, Spear RC. A video imaging technique for assessing dermal exposure. II. Fluorescent tracer testing. American Industrial Hygiene Association Journal. 1986;47(12):771-5.
21. Aragon A, Blanco L, Lopez L, Liden C, Nise G, Wesseling C. Reliability of a visual scoring system with fluorescent tracers to assess dermal pesticide exposure. The Annals of Occupational Hygiene. 2004;48(7):601-6.
22. Cherrie JW, Brouwer DH, Roff M, Vermeulen R, Kromhout H. Use of qualitative and quantitative fluorescence techniques to assess dermal exposure. The Annals of Occupational Hygiene. 2000;44(7):519-22.
23. Bierman EP, Brouwer DH, Van Hemmen JJ. Implementation and evaluation of the fluorescent tracer technique in greenhouse exposure studies. The Annals of Occupational Hygiene. 1998;42(7):467-75.
24. Behroozy A. On dermal exposure assessment. The international journal of occupational and environmental medicine. 2013;4(3):113-27.
25. Fenske RA. Dermal exposure assessment techniques. The Annals of Occupational Hygiene. 1993;37(6):687-706.
26. Hautemaniere A, Diguio N, Daval MC, Hunter PR, Hartemann P. Short-term assessment of training of medical students in the use of alcohol-based hand rub using fluorescent-labeled hand rub and skin hydration measurements. American Journal of Infection Control. 2009;37(4):338-40.