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Brandsäkerhet för en åldrande befolkning – fördjupad problembeskrivning och diskussion om framtidens utmaningar och lösningar

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Brandforsk

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Sökord: dödsbränder, bostadsbrand, räddningstjänst, utrymning

Keywords: Fire fatality; Rescue services; Non-fatal injury; Evacuation; Residential fires

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Förord

I denna rapport redovisas resultat av det avlutande projektet i en serie på tre om brandsäkerhet för äldre personer. Projekten har finansierats av Insamlingsstiftelsen Brandforsk som arbetar för att minska de negativa konsekvenserna av bränder i samhället genom kunskapsutveckling och kunskapsspridning finansierat via sina stödorganisationer. Rapporten innehåller också en övergripande syntes som bygger på den samlade kunskapen från de tre projekten.

Projekten har ur olika perspektiv undersökt problematiken med dödsbränder bland äldre personer genom att beskriva orsaker samt bygga ny kunskap om hur riskerna för brand i bostad hos denna grupp kan minskas. Den sammanlagda projekttiden sträcker sig från 2018 till hösten 2020 och i denna rapport presenteras resultaten från delstudie tre samt en syntes från samtliga tre projekt.

De två första projekten är *Bostadsbränder och äldre personer – tvärvetenskapliga framgångsfaktorer för reducering av döda och svårt skadade* (*Brandforsk 202-171*) samt *Framgångsfaktorer vid bostadsbränder (Brandforsk 301-151).* Samtliga publikationer som projekten genererat finns listade under rubriken Fortsatt läsning sist i dokumentet.

Det tredje projektet, som tillsammans med sammanfattning av de tre delprojekten, redovisas i denna rapport är *Brandsäkerhet för en åldrande befolkning – fördjupad förståelse för framtidens utmaningar och lösningar* (Brandfors 202-181). Projektet har genomfört i samverkan mellan Karlstads universitet och Lunds universitet och projektgruppen har bestått av följande personer:

- Johanna Gustavsson, Karlstads universitet (projektledare)
- Finn Nilson, Karlstads universitet
- Anders Jonsson, Myndigheten för samhällsskydd och beredskap
- Marcus Runefors, Lunds universitet
- Margaret Mcnamee, Lunds universitet
- Gunilla Carlsson, Lunds universitet

Projektettiden är 2019-09-01 till 2020-08-31 och arbetet har följts upp av en referensgrupp bestående av följande personer;

- Mattias Delin, Brandforsk
- Lynn Ranåker, Räddningstjänsten Syd
- Anders Lundberg, MSB
- Nina Bergström, Stor Stockholms Brandförsvar
- Christofer Strandberg, Räddningstjänsten Östra Götaland
- Kjell Fallqvist, Brandkonsulten

Referensgruppens aktiva medverkan i projektet uppskattas och ett särskilt tack riktas till dess medlemmar.

Sökord: dödsbränder, bostadsbrand, räddningstjänst, utrymning

Keywords: Fire fatality; Rescue services; Non-fatal injury; Evacuation; Residential fires

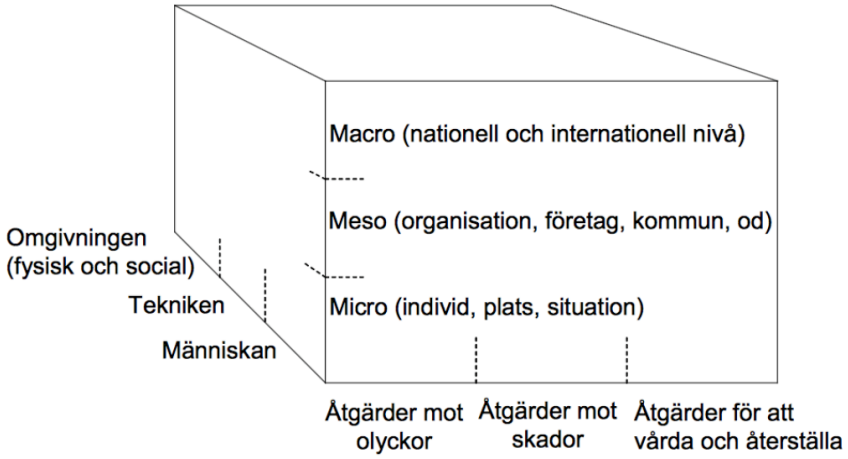
Bakgrund och forskningsläge

Även om antalet omkomna i bränder i Sverige minskat sedan 1950-talet är brandrelaterad dödlighet fortfarande ett problem med omkring 100 döda per år i bränder (Jonsson, Runefors, Särdqvist, & Nilson, 2015). Sett utifrån ett trendperspektiv har minskningen i antalet döda dessutom nära nog avstannat de senaste 10-15 åren, trots en etablerad nollvision (MSB, 2010). Av de dödsbränder som inträffar årligen i Sverige så sker omkring 75 procent i bostaden (Jonsson, Bonander, Nilson, & Huss, 2017), och flera studier har påvisat betydande skillnader i risken för brand och risken för skada och dödsfall vid brand mellan olika åldersgrupper, socioekonomiska grupper och geografiska områden (t.ex. (Guldåker & Hallin, 2014; Jonsson et al., 2017)). En grupp som återkommer som särskilt utsatt är äldre personer (Gustavsson & Nilsen, 2017; Jonsson et al., 2017). Denna grupp utgör även de som procentuellt sett ökar mest i populationsstorlek (OECD, 2003) vilket gör att vi kan anta att problemet kommer att öka.

Trots att äldre är överrepresenterade i brandrelaterade dödsfall, är risken för bränder i denna grupp, oavsett behov av räddningstjänst eller omfattning, relativt låg (Nilson, Bonander, & Jonsson, 2015). Det innebär att risken för en äldre personer att omkomma i en bostadsbrand är hög jämfört med yngre åldersgrupper. När det gäller den ökade risken för äldre personer har flera faktorer av betydelse identifierats, det gäller tidsaspekter (att förhindra olyckan, att förhindra skadan, och förhindra konsekvenserna) men också specifika aspekter vad gäller komponenterna; bäraren, värden, och den omgivande miljön (Haddon, 1980). Till exempel har vi identifierat att äldre oftare än genomsnittet har fungerande brandvarnare vilket bör innebära att möjligheterna till upptäckt är stora, sett utifrån populationen i stort (Finn Nilson & Carl Bonander, 2020).

Problemet med riskökningen för äldre personer kan närmas från flera olika vetenskapliga discipliner. Från ett medicinskt/tekniskt perspektiv, i enlighet med t.ex. Haddons preventionsteorier (Haddon, 1980), kan risken för att omkomma i en brand minskas vid flera stadier, från det att ett startobjekt börjar brinna till dess att individen ådrar sig skador så omfattande att denne avlider. Haddon kompletterade också sina strategier genom en matris där tre olika tidsbaserade preventionsalternativ förtydligades; att förhindra olyckan, att förhindra skadan, eller begränsa konsekvenserna av skadan.

Även om den medicinska/tekniska preventionsmatrisen som utvecklades av Haddon är viktig och praktisk användbar, finns också preventions- och förklaringsmekanismer som snarare kan fördelas på olika samhällsnivåer och som ligger utanför den ofta studerade individen. I ett försök att inkludera dessa element har den s.k. preventionskuben utvecklats där de tre nivåerna makro (nationell och internationell nivå), meso (organisation, kommun, m.m.) och mikro (individ, plats, m.m.) finns inkluderade (figur 1).



Figur 1. Preventionskuben (R. Andersson & Menckel, 1995)

Uppdelat i dessa nivåer syns både risk- och skyddsfaktorer vad gäller äldre och bostadsbränder. Från ett makroperspektiv har den s.k. kvarboendeprincipen, det vill säga den nuvarande samhällsinriktningen som eftersträvar att äldre personer ska bo kvar i sin bostad så länge som möjligt, varit diskuterad som en potentiell riskfaktor utifrån ett brandskyddsperspektiv (Jönsson & Gustavsson, 2017), inte minst då ensamboende identifierats som en betydande aggregerad riskfaktor för dödlighet på nationellnivå (Nilson, Lundgren, & Bonander, 2020). Den demografiska förskjutningen som innebär en allt större andel multisjuka äldre adderar till problematiken och skapar nya utmaningar. I regeringens utredning av vårdens effektivitet pekar man på att hinder för att hantera denna utmaning är förknippade med den sjukhustunga organisation som Sverige har idag (SOU 2016:2). Lösning som föreslås är att i större utsträckning flytta vården till patientens hem och till särskilda boenden, där en stärkt primärvården i samverkan med kommunal sjukvård kan möta de ökande behoven av vård hos multisjuka äldre. Detta ställer nya krav på brandskyddet som i stor utsträckning utgår från att personer själva ska kunna utrymma sin bostad.

Också kulturella eller strukturella faktorer kan vara relevanta, såsom det faktum att Sverige som helhet, till skillnad mot många andra länder, har en stor andel ensamhushåll, en faktor som tycks öka effekterna av bränder (Vermina Lundström & Andersson, 2018). Här kommer samhällets preventiva ansvar in som en faktor med potential att minska problem. Det har dock visat sig finnas varierande förutsättningar och en rad hinder för att införa individanpassade åtgärder (Jönsson & Gustavsson, 2017). Också på meso- och mikronivån finns det faktorer som hypotetiskt kan öka eller minska mortalitetsrisken. Agerande från allmänheten eller hemtjänsten, tid till ankomst för räddningstjänst och kunskap till följd av förebyggande information är exempel på skyddsfaktorer som tidigare studier berört (t.ex. (Jaldell, 2015) och (Sund, Bonander, Jakobsson, & Jaldell, 2019)). På mikronivå kan fysiska och mentala faktorer, så som nämnts ovan, påverka risken avsevärt men också tekniska hjälpmedel eller utbildning.

Om vi ska kunna möta framtidens utmaningar behöver vi ta till vara alla resurser som står till buds och räddningstjänsten utgör i detta sammanhang en viktig aktör. I utredningen om den kommunala räddningstjänstens effektivitet föreslås en förändrad styrning av den förebyggande verksamheten mot en tydligare målsättning att det är effektiva åtgärder som ska genomföras (SOU 2018:54). Tidigare har det preventiva arbetet ofta riktat sig mot befolkningen i stort men många av de traditionella åtgärderna har visat sig vara ineffektiva i att förebygga dödsbränder bland äldre (Marcus Runefors, Johansson, & van

Hees, 2017). Utifrån denna kunskap behöver åtgärder riktade mot gruppen äldre beskrivas tydligare, i relation till kunskapen om hur skadan uppkommer.

Delprojekt tre

I följande avsnitt presenteras syfte och metod för delprojekt tre. Resultaten från projektet återfinns i avsnittet som sammanfattar resultaten från de tre delprojekten samt i bilaga ett, två och tre.

Syfte och mål

Målet med detta projekt är att identifiera möjligheter till prevention för att minska antalet äldre som omkommer eller skadas allvarligt i bostadsbrand och genom det bättre kunna möta utmaningen som det innebär att en allt större andel riskutsatta äldre bor i egen bostad. Projektet syftar till att beskriva gruppen äldre som omkommer vad avser sociala faktorer, bostadens beskaffenhet, medicinska variabler samt brandens karaktär. Vidare ämnar vi beskriva de preventionsmöjligheter som finns eller möjligen saknas i relation till de äldre riskutsatta. Det sista steget syftar till att problematisera möjligheter och hinder för att i samverkan mellan samhällets aktörer genomföra åtgärder riktade mot målgruppen.

Metod

Projektet är uppdelat i fyra olika arbetspaket:

1. En fördjupad problembeskrivning,

Det har tidigare med framgång genomförts en så kallad klusteranalys på de som omkommit i bostadsbrand (Jonsson et al., 2017). Resultatet visade då att det finns sex typhändelser (kluster) som leder till dödsfall. Analysen, som är unik i brandsammanhang, ger värdefull information till det förebyggande arbetet genom sin beskrivning av karakteristika för både individerna och branden. I dessa analyser ingick dock samtliga dödsbränder oavsett ålder vilket innebär att medan kunskapen kan ge en fingervisning om hur situationen ser ut för en särskild grupp kan det mycket väl vara missvisande. Vi avser därför att göra om klusteranalysen på enbart gruppen över 65 år för att se vilka mönster som då avslöjar sig. Syftet är att genom en noggrannare beskrivning av händelsernas karaktär bättre kunna avgöra vilka åtgärder som har god teoretisk evidens att var effektiva. Resultatet presenteras i bilaga ett samt slutsummeringen.

2. Analys av åtgärder/lösningar,

I detta arbetspaket utgår vi från resultatet av klusteranalysen i steg ett, och kombinerar det med tidigare kunskap om metoder för att förhindra dödsbränder (M Runefors, Johansson, & van Hees, 2016). Syftet är att beskriva åtgärder som på olika nivåer i samhället med nuvarande kunskap kan antas vara effektiva. Vi utgår framför allt från idag kända åtgärder men utifrån kunskapen i det tidigare Brandforsk-finansierade projektet Bostadsbränder och äldre personer – tvärvetenskapliga framgångsfaktorer för reducering av döda och svårt skadade kan också nya lösningar diskuteras. Resultatet kommer att presenteras i slutsummeringen och i bilaga två.

3. Beskrivning av förutsättningar för implementering,

Även med evidensbaserade metoder till hands är det inte givet att problemet minskar, för en faktisk effekt behöver metoder spridas med hjälp av implementeringsaktiviteter. I detta arbetspaket har vi med en programteoretisk utgångspunkt problematiserat förutsättningarna för implementering av individanpassat brandskydd i svenska kommuner. Data består främst av intervjuer med representanter från räddningstjänsten, men även riktlinjer och andra dokument har använts i analysen. Genom att identifiera hinder och möjligheter för införande av effektiva metoder skapas en grund för en framgångsrik implementering, och för detta har ramverket Consolidated Framework For Implementation Research (CFIR) använts (Damschroder et al., 2009). Resultatet presenteras i bilaga tre samt slutsummeringen.

4. Syntes och slutsatser,

I denna del görs en sammanställning av samtliga arbetspaket och övergripande slutsatser dras. Till dessa läggs även slutsatser från de två tidigare delprojekten, *Framgångsfaktorer vid bostadsbränder* samt *Bostadsbränder och äldre personer – tvärvetenskapliga framgångsfaktorer för reducering av döda och svårt skadade*. Vår förhoppning är att denna del ska utgöra ett värdefullt underlag för beslutfattare inom området brandskydd på nationell, regional och lokal nivå samt för den enskilde. Resultatet presenteras i slutsummeringen.

Äldre personer och risk för brand i bostad - sammanfattande resultat och diskussion

Det övergripande målet med de tre projekten är att fördjupa förståelsen för orsakerna till att äldre personer är överrepresenterade i bostadsbränder med dödlig utgång och vad som kan göras för att minska risken för denna typ av händelser. Genom att angripa dödsbrandsproblematiken bland äldre personer med en tvärvetenskaplig och multidisciplinär ansats, där preventionskuben och skyddsfaktorer varit vägledande, har de tre delprojekten försökt generera ny kunskap och fördjupa problembilden, identifiera orsaker till problemet och beskrivit åtgärder som har potential att vara effektiva.

Sårbarhetens betydelse för risk

Individens förmåga att hantera en brandhändelse har en avgörande betydelse för utgången. Dock finns problem vad gäller äldre personers upptäckande och agerande vid bränder, som följd av den ökade risken av fysiska och psykiska funktionsnedsättningar som medföljer åldrandet. Funktionsnedsättningar såsom minnesproblematik, syn- eller hörselnedsättningar, nedsättningar i rörelseförmåga eller styrka, m.m. kan påverka möjliga insatser, tid samt effektivitet av insatser (Gilbert & Butry, 2017). Därtill ska tilläggas den ökade skörheten och minskad motståndskraft till yttre påfrestningar som ålderdomen medför (Eggert & Huss, 2017).

De åtgärder som traditionellt används i det brandpreventiva arbetet riskerar att inte vara lika effektiva för gruppen äldre personer. Om vi tar exemplet brandvarnare som oftare förekommer i bränder med lyckad utgång (Finn Nilson & Carl Bonander, 2020), så kan det vara en åtgärd som har begränsad effekt för en grupp med nedsatt förmåga att reagera och agera på larmet. Det har också visat sig att det bland de som omkommer i en bostadsbrand finns en kategori av händelser som drabbar personer över 80 år där orsaken är brand i kläder (Jonsson et al., 2017). För denna typ av händelse är förloppet mycket snabbt och det är oklart om det finns effektiva preventiva metoder att ta till. Det blir vid dessa tillfällen avgörande att ha personer i sin närhet som kan bistå i att förhindra att en brand utvecklar till en dödsbrand. Samboende bland den generella befolkningen, men i synnerhet bland äldre personer, är en känslig samhällelig fråga som berör djupa ideologiska och kulturella aspekter. Medan vi historiskt har bott i täta familjegrupper har det sedan 1980-talet funnits en samhällstrend i Sverige och Europa som innebär att äldre personer alltmer bor ensamma (De Jong Gierveld & Van Tilburg, 1999) och är en trend som förutspås öka (Iacovou, 2000). Då samboendets effekter syns i en europeisk jämförelse (Nilson et al., 2020) är det föga förvånansvärt att ensamboende/samboende visats vara en av de viktigaste risk- och skyddsfaktorerna också inom Sverige (Jonsson et al., 2017; Jonsson & Jaldell, 2019; Marcus Runefors et al., 2017).

På mesonivån kan kommuner ha svårt att kompensera sårbarheten genom hemtjänsten eller blåljusmyndigheter och därmed blir att evakuera självmant eller med samboende/grannar eftersträvansvärt, inte minst med bakgrund i tidsfaktorns betydelse i att rädda liv (Jaldell, 2015). Trots detta evakuerar enbart drygt 50 % av äldre sig själva eller med hjälp av grannar, utifrån samtliga bränder som räddningstjänsten larmats till. Risken att inte klara evakueringen själv eller med hjälp av grannar ökar bl.a. vid högre ålder samt i kommuner med lägre populationstäthet. På individ- eller mikronivån innebär makro- och mesoförändringar att andra skyddsfaktorer kan behöva ersätta eller komplettera samhällets skyddsnät. En person kan undkomma en brand genom att utrymma själv, få hjälp av grannar,

få hjälp av hemtjänst eller få hjälp av blåljusmyndigheter. Här finns även en potential i förstärkning av frivillig insatser, ett område där det för tillfället pågår ett expansivt utvecklingsarbete (T. Andersson, Fredriksson, A., Pilepalm, S., Mojir, K. Y., 2017).

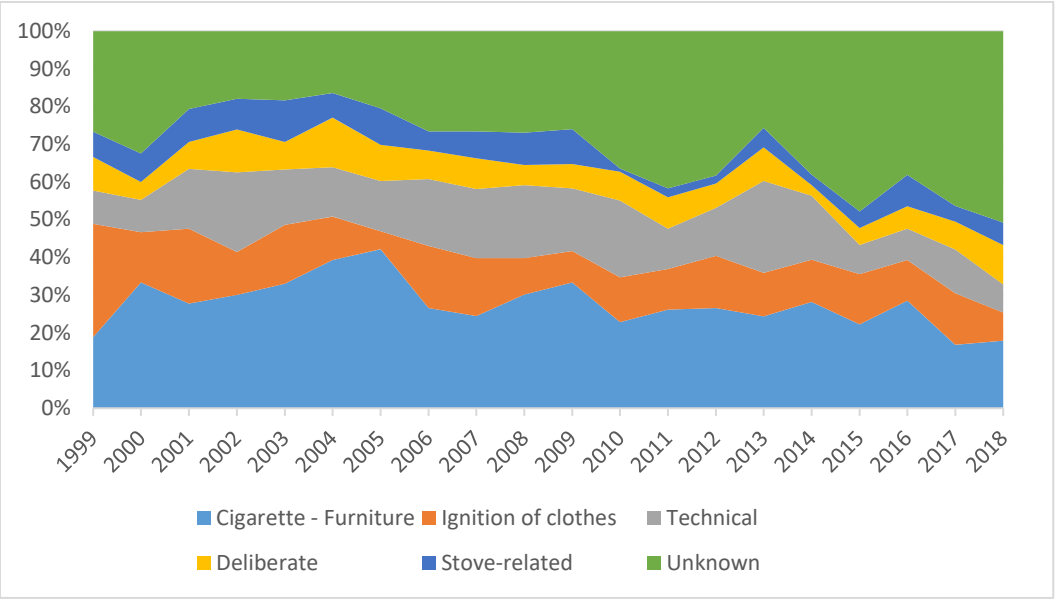
Skadedata och underlag för utformning av prevention

Fördjupad skadebild

Ett genomsnitt för avlidna i bostadsbrand har under de senaste tio åren varit ca 100/år. De som avlider i bränder är dock inte jämt fördelade i populationen och tidigare har typhändelser baserat på data från 1999-2007 identifierats (Jonsson et al., 2017). En liknande analys har nu gjorts om, baserat på händelser till och med utgången av 2018. Sex kluster identifierades och beskrivs nedan med statistisk signifikanta karakteristiska inkluderat:

1. **Brand i kläder**. Antändning i kläder av ljuslåga eller cigaretter (246 st, vilket utgör 13 % av händelserna). I denna grupp är äldre kvinnor överrepresenterade, de var sällan påverkade av alkohol eller antidepressiva läkemedel. Branden var vanligen begränsad i omfattning, förekom på vårdboenden och uppkom under dagtid under vintern.
2. **Brand i möbler.** Antändning i möbler orsakade av cigarett (513 st, vilket utgör 28 % av händelserna). De avlinda var oftast mellan 45 och 79 år gamla, bodde ensamma och var påverkade av alkohol. Den vanligaste bostaden var en lägenhet i medelstora samhällen.
3. **Tekniska fel.** Brand som orsakats av tekniska fel eller uppvärmningsutrustning (272 st, vilket utgör 15 % av händelserna). Ingen köns eller åldersspecifik grupp kunde utskiljas i detta kluster, men förekom oftare i villor och orsakade flera dödsfall vid samma händelse. Dödsorsaken var vanligen rökgaser.
4. **Brand i matlagningsutrustning.** Brand som orsakats av spisar som lämnats obevakade (118 st, vilket utgör 6 % av händelserna). De drabbade var vanligen 65-74 år gamla, boende i lägenhet och dödsorsaken var rökgaser. Ofta vad alkohol och lugnande medel involverat samt att händelsen skedde på helgnätter.
5. **Anlagda bränder** (140 st, vilket utgör 8 % av händelserna). Offren vad ofta män. Alkohol var sällan involverat, emedan illegala droger oftare förekom. Avsiktlig antändning av lättantändliga vätskor var en vanlig brandorsak.
6. **Okänd orsak.** Händelser där brandorsaken var okänd (567 st, vilket utgör 31 % av händelserna). Denna typ av händelser var vanligare i villor med avlidna i åldern 45-79 år. Bränderna var ofta omfattande, uppstod på natten, på landsbygden och under vintern.

Jämfört med den tidigare artikeln är typbränderna som identifierats med nästan dubbelt så mycket data i stort sätt likvärdiga. Detta tyder på stabilitet i både data och analys vilket innebär att preventiva åtgärder bör kunna riktas mot dessa kluster. En mer oroande utveckling är att sett över 20 årsperioden har fördelning mellan typbränderna förändrats. Som ses i figuren nedan har i synnerhet andelen bränder med okända orsaker ökat.



Denna ökning kan tolkas på flera olika sätt. Dels kan ökningen representera en procentuell nedgång av övriga bränder, eventuellt till följd av framgångsrikt preventivt arbete. Dels kan förändringen indikera en förändring i rutiner kring olycksundersökningar, antingen genom mer omfattande krav på evidens av orsaker och brandförlopp eller till följd av begränsade resurser/kompetens kring utredningar. Slutligen skulle också förändringen kunna indikera en faktisk uppgång av bränder med okänd orsak.

Då de nya analyserna innehåller betydligt mer data kunde specifika klusteranalyser genomföras på gruppen äldre för att undersöka huruvida de dödsbränder som drabbar denna särskilt sköra och sårbara grupp är annorlunda. Resultaten visade dock förvånansvärt samstämmiga resultat jämfört med den totala befolkningen;

1. **Brand i kläder**. Antändning i kläder av ljuslåga eller cigaretter (189 st, vilket utgör 19 % av händelserna). De avlidna var oftast en äldre kvinna som dog av brännskador och som inte varit påverkad av alkohol eller antidepressiva läkemedel. Branden var vanligen begränsad i omfattning, förekom på vårdboenden och uppkom under dagtid under vintern.
2. **Brand i möbler.** Antändning i möbler orsakade av cigarett (254 st, vilket utgör 26 % av händelserna). De avlinda var oftast mellan 65 och 79 år gamla, bodde ensamma och var påverkade av alkohol. Den vanligaste bostaden var en lägenhet i medelstora samhällen.
3. **Tekniska fel.** Brand som orsakats av tekniska fel eller uppvärmningsutrustning (72 st, vilket utgör 7 % av händelserna). De som omkom var oftare över 90 år, bodde oftare i större samhällen och dog vanligen av brandgaser.
4. **Brand i matlagningsutrustning.** Brand som orsakats av spisar som lämnats obevakade (49 st, vilket utgör 5 % av händelserna). De drabbade var vanligen 64-69 år gamla, påverkade av alkohol och/eller lugnande medel. Dödsorsaken var rökgaser.

5. **Anlagda bränder och eldstadsbränder** (114 st, vilket utgör 12 % av händelserna). Trots olika brandorsaker fanns flera likheter bland offren. Dessa var ofta män och mellan 70-79 år. Bränderna var ofta stora och skedde under dagen, oftare på landsbygden.
6. **Okänd orsak.** Händelser där brandorsaken var okänd (295 st, vilket utgör 30 % av händelserna). Ingen ålder- eller könsspecifika grupper var överrepresenterade men bränderna var ofta omfattande, uppstod på natten, på landsbygden och under vintern.

Vidare analyser genomfördes också på materialet som omfattade den äldre gruppen genom att exkludera både avsiktliga och okända orsaker. Detta ledde inte till fler kluster vilket ytterligare stödjer stabiliteten och robustheten i analyserna.

Då andelen bränder med okända orsaker var så pass omfattande samt ökat under den studerade perioden gjordes en analys av hur de okända fallen skilde sig från de kända fallen. Sammanfattningsvis (vilket också antyddes i klusteranalysen) tyder resultaten på att de okända fallen utmärker sig genom att vara stora bränder som sker i hus, på landsbygden och på natten. Det var också oftare bränder som ledde till fler än ett dödsfall. Detta tyder på att det sannolikt funnits begränsat med material att studera men också att räddningstjänsten av olika skäl inte hunnit fram till platsen i tid, alternativt inte kunnat släcka, vilket inneburit att branden utvecklats till en stor och omfattande brand. Oavsett vilket, så väcker ökningen av dessa typer av bränder många frågor i relation till räddningstjänstens organisering, responstider och det individuella ansvaret.

För brandområdet finns omfattande dokumentation, både vad gället detaljer om branden och efterföljande skador på person och egendom. Som visats i detta arbetspaket så innebär det att detaljerade beskrivningar av dödsbränder kan tas fram. Trots mängden data och dess i stort goda kvalitet, så saknas dock vissa uppgifter för dödsbränder som skulle vara användbara för utformning av preventiva åtgärder. Uppgifter om brandens orsak saknas exempelvis i ca 30 % av fallen. Vidare saknas uppgifter om den drabbade individen som exempelvis förekomst av trygghetslarm, hemtjänst och olika typer av vårdboende. Avsaknaden av dessa uppgifter försvårar möjligheten att utforma åtgärder som är anpassade till individens förutsättningar.

Effektiva åtgärder

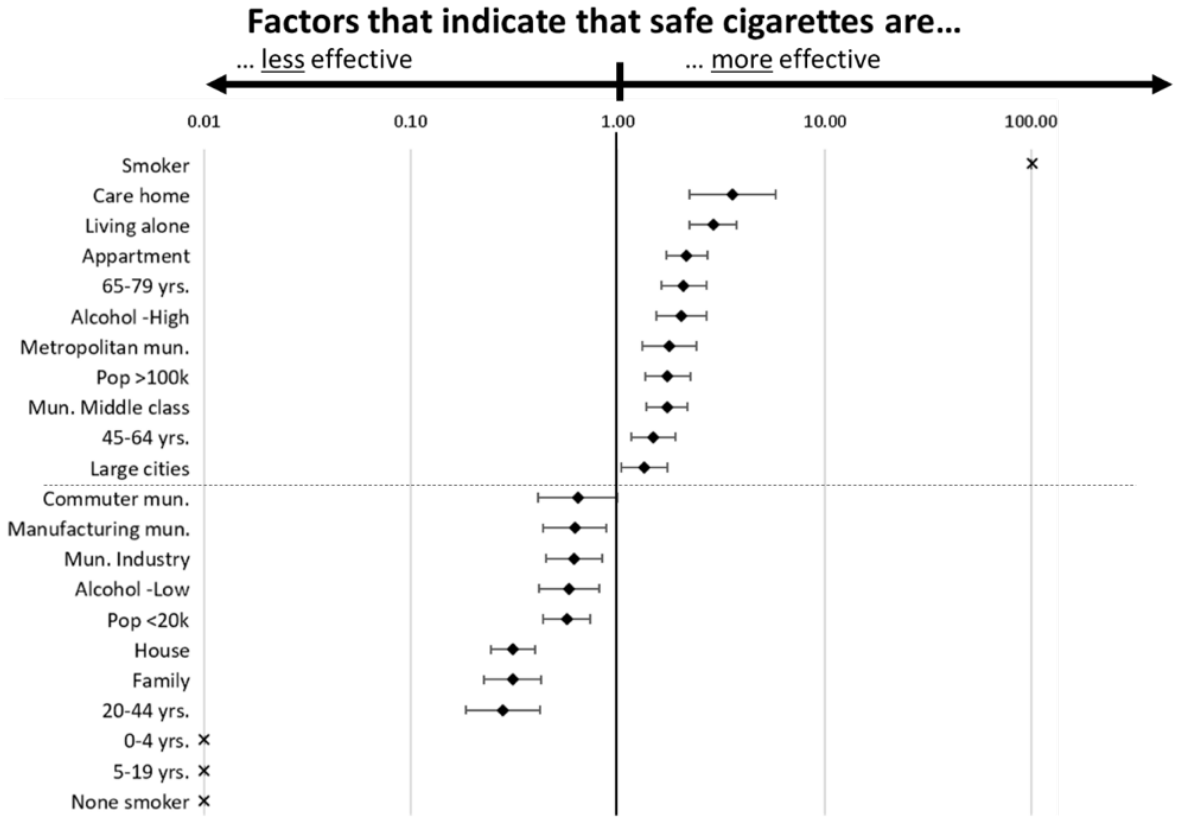
Genom att använda sig av kunskapen kring den teoretiska effektiviteten för specifika preventiva interventioner (Runefors et al, 2017), är det möjligt att bedöma vilka grupper som skulle ha störst nytta av att anamma interventionerna. Likaså är det möjligt att bedöma vilka grupper som inte skulle ha nytta av dem. Totalt analyserades nio olika förebyggande åtgärder.

I en studie med fall-kontroll design har händelser där en viss åtgärd hade varit effektiv jämförs med de där åtgärden inte hade varit effektiv. Det som jämförs är oddsen för att en viss faktor finns i den ena gruppen jämfört med den andra. Resultatet presenteras som odds ratio (OR) där OR på 1 innebär att den undersökta faktorn (t.ex. att personen bor i en lägenhet) är lika vanlig i båda grupperna. Studiens fall är de händelser där en åtgärd hade kunnat förhindra dödsfallet och kontroller där de inte hade kunnat det. En OR över 1 betyder att den undersökta faktorn är mer vanligt förekommande vid händelser där åtgärden hade kunnat förhindra dödsfallet.

Det innebär att om man vill göra en förebyggande insats i t.ex. en lägenhet så bör man normalt leta efter åtgärder där faktorn lägenhet har en OR över 1 och på motsvarande sätt undvika åtgärder som har en OR

under 1. Endast faktorer som har en statistiskt signifikant påverkan på effektiviteten presenteras i nedanstående diagram.

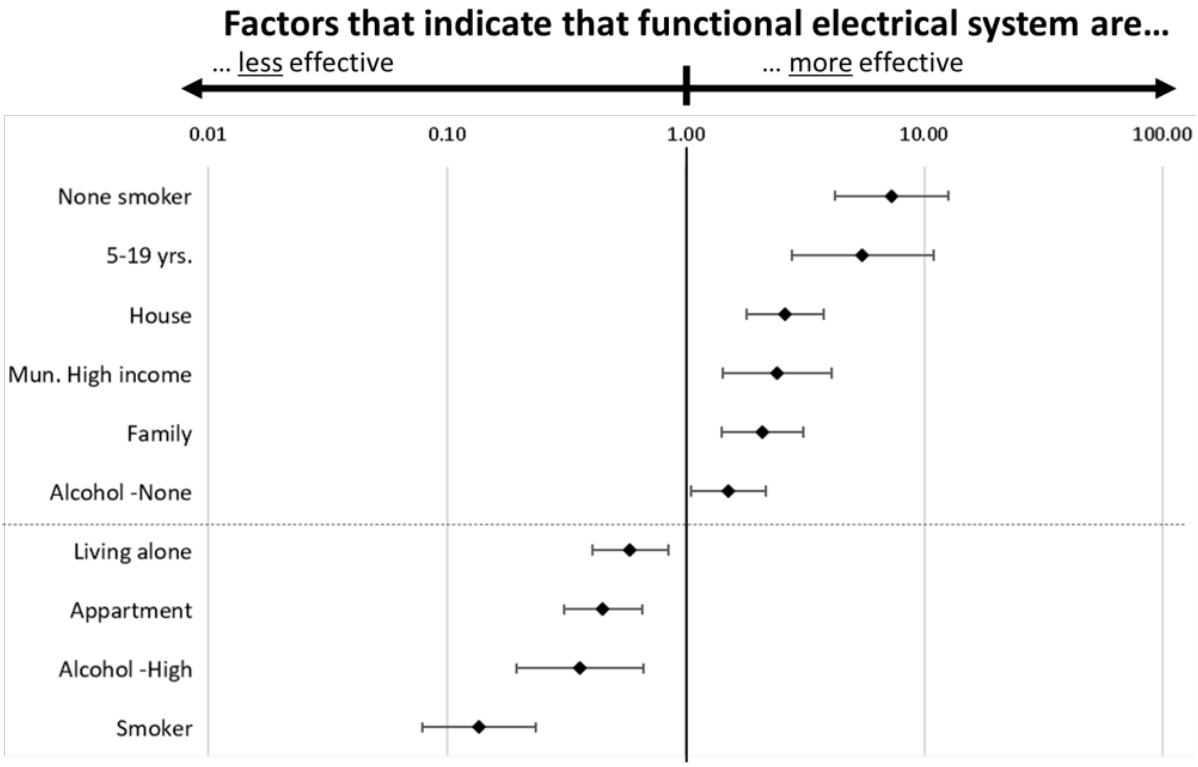
Säkra cigaretter



Som syns i figuren är säkra cigaretter mest effektiva för rökare. Men även de som bor i ett vårdhem (OR = 3,6; 95% KI, 2,2 - 5,8) följt av att bo ensam (OR = 2,9; 95% KI, 2,2 - 3,8) och i lägenhet (OR = 2,2; 95% KI, 1,7 - 2,7). Effektiviteten är också relaterad till ålder, särskilt mellan 65 och 79 år (OR = 2,1; 95% KI, 1,6 - 2,7), alkoholintag (med en OR på 2,0 (95% KI, 1,5-2,7) för BAC över 2 ‰) och boende i större städer med en befolkning över 100 000 (OR = 1,7; 95% KI, 1,4 - 2,2).

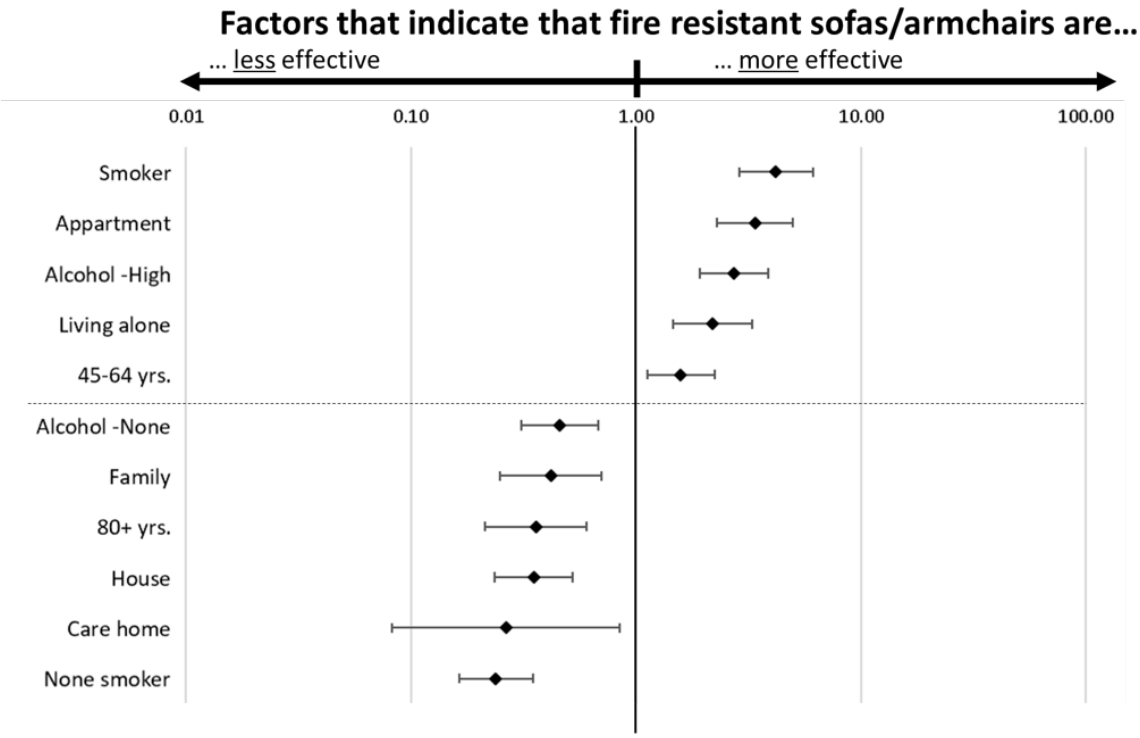
Många av de faktorer som indikerar en lägre effektivitet är motsatsen till de faktorer som beskrivs ovan. Till exempel yngre åldrar (20-44 år, OR på 0,3 (95% KI, 0,2 - 0,4)) att bo med andra (OR = 0,3; 95% KI, 0,2 - 0,4), bo i hus (OR = 0,3; 95% KI, 0,2 - 0,4) samt att bo i mindre städer.

Säkra elsystem



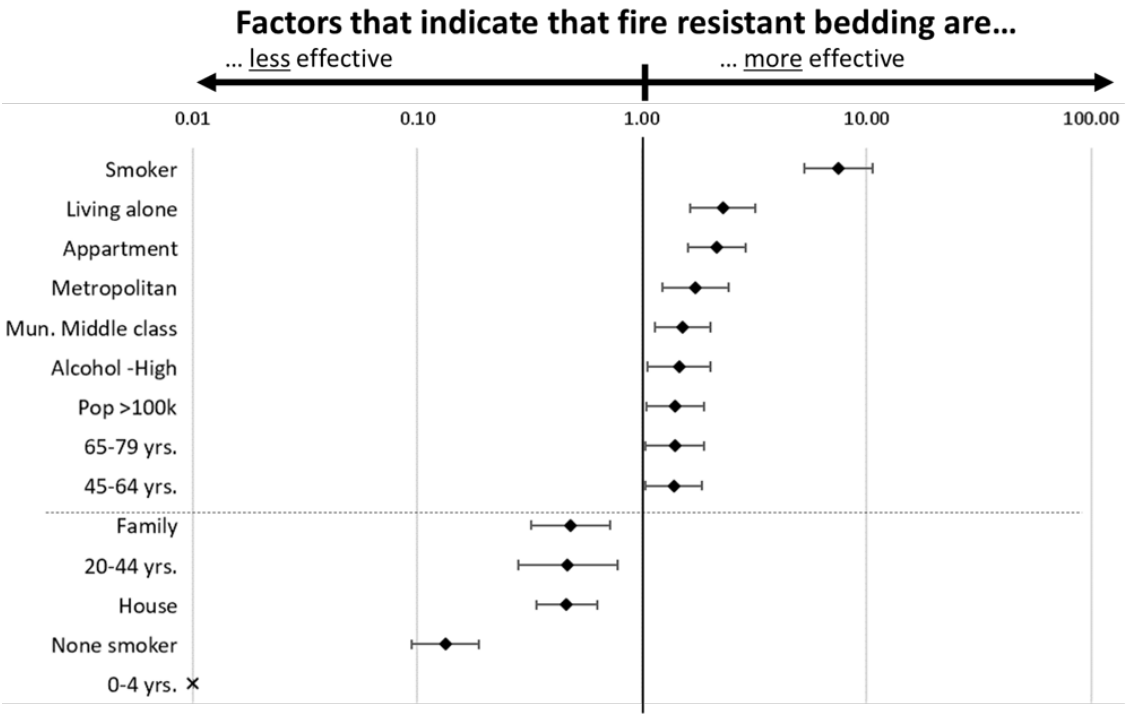
Ett säkert elsystem relaterar till både fasta installationer och elektriska produkter. Den starkaste indikatorn för effektivitet är frånvaron av rökning (OR = 7,3; 95% KI, 4,2 - 12,6) vilket indikerar att dessa individer skulle ha större nytta av åtgärder som riktar sig till rökningsrelaterade bränder. Även yngre människor (5-19 år (OR = 5,5; 95% KI, 2,8 - 10,9)), de som bor i hus (OR = 2,6; 95% KI, 1,8 - 3,8) samt de som bor med andra (OR = 2,1; 95% KI , 1.4 - 3.1) verkar ha större nytta av denna intervention. Även människor i höginkomstkommuner (OR = 2,4; 95% KI, 1,4 - 4,1) och personer som inte är påverkade av alkohol (OR = 1,5; 95% KI, 1,1 - 2,2) tenderar att dra större nytta av denna åtgärd.

Flamskyddade soffor och fåtöljer



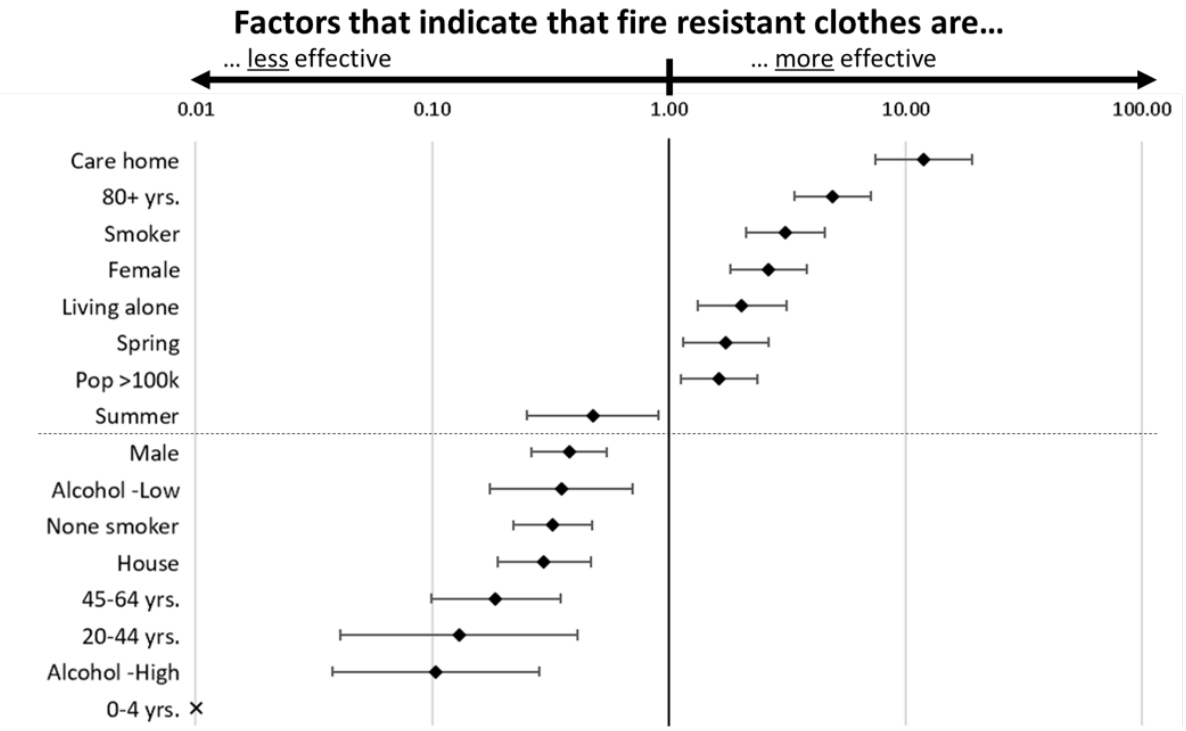
Bland de faktorer som indikerar hög effektivitet av flamskyddade soffor och fåtöljer är rökning (OR = 4,2; 95% KI, 2,9 - 6,1), boende i lägenhet (OR = 3,4; 95% KI, 2,3 - 5,0), en BAC över 2 ‰ (ELLER = 2,7; 95% KI, 1,9 - 3,9), ensamboende (OR = 2,2; 95% KI, 1,5 - 3.3) och åldersgruppen 45-64 år (OR = 1,6; 95% KI, 1,1 - 2,2). Låg effektivitet är i hög grad motsatsen av dessa faktorer, men det är intressant att notera att den äldsta åldersgruppen, 80+, indikerade en låg effektivitet (OR = 0,4; 95% KI, 0,2 - 0,6) samt för dem som bor på vårdhem (OR = 0,3; 95% KI, 0,1 - 0,8).

Flamskyddade sängkläder



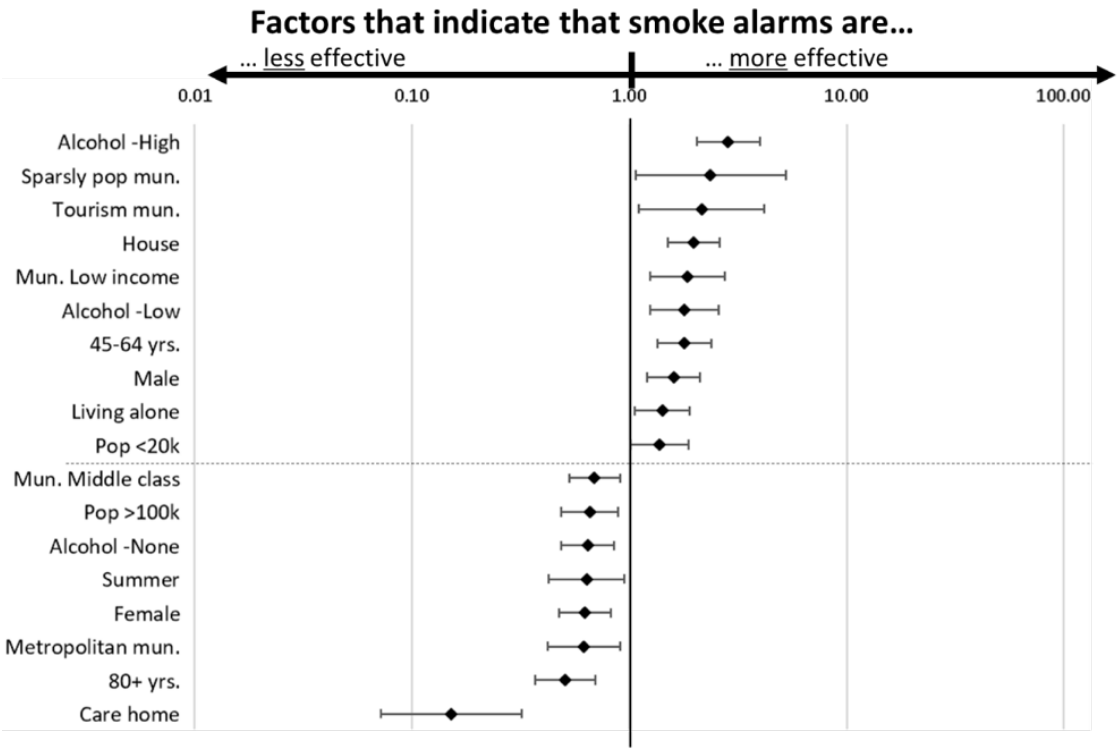
Dessa faktorer liknar till stor del de faktorer som finns för flamskyddade soffor och fåtöljer, dock med vissa skillnader. Till exempel att individer som bor i storstadskommuner (OR = 1,7; 95% KI, 1,2 - 2,4) och medelinkomstkommuner (OR = 1,5; 95% KI, 1,1 - 2,0) kan förväntas dra nytta av flamskyddade sängkläder.

Flamskyddade kläder



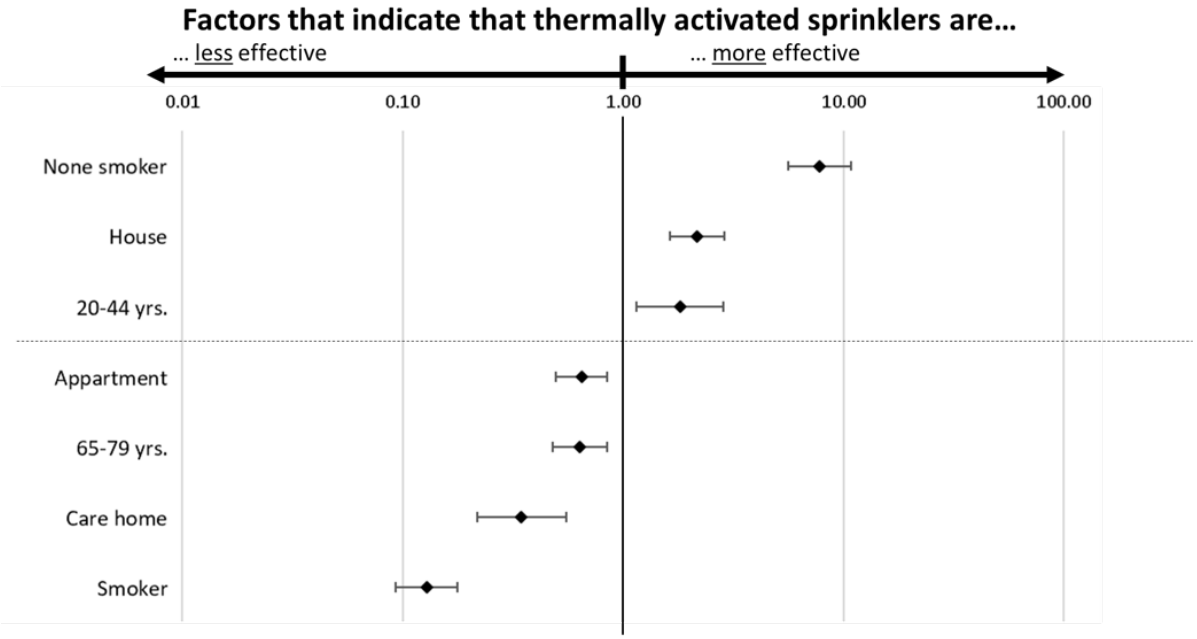
Grupperna som förväntas ha en hög effektivitet av flamskyddade kläder skiljer sig från de som presenterats ovan. Denna intervention gynnar den äldsta gruppen, 80+ år (OR = 4,9; 95% KI, 3,4 - 7,1) och de som bor i vårdhem (OR = 11,9; 95% KI, 7,4 - 19,1). Personer med måttliga (OR = 0,4; 95% KI, 0,2 - 0,7) eller höga (OR = 0,1; 95% KI, 0,0 - 0,3) alkoholnivåer gynnas mindre. Det verkar också finnas en könsskillnad där effektiviteten är högre för kvinnor (OR = 2,6; 95% KI, 1,8 - 3,8) än för män (OR = 0,4; 95% KI, 0,3 - 0,5).

Brandlarm



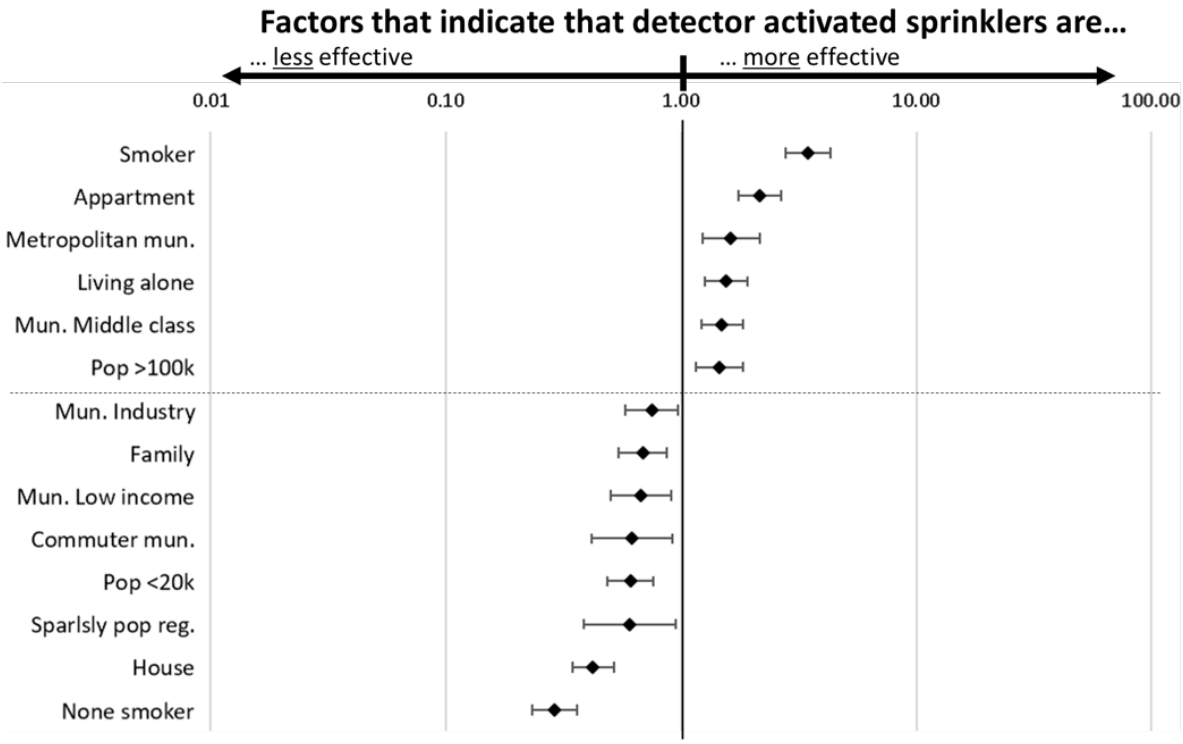
Bland de faktorer som ökar effektiviteten av brandlarm är både höga (OR = 2,8; 95% KI, 2,0 - 4,0) och låga alkoholnivåer (OR = 1,8; 95% KI, 1,2 - 2,6) samt boende i mer glesbefolkade kommuner (OR = 2,4; 95% KI, 1,1 - 5,2), kommuner med låg genomsnittlig inkomst (OR = 1,9; 95% KI, 1,2 - 2,8) samt för människor som bor i hus (OR = 2,0; 95% KI, 1,5 - 2,6).

Värme-aktiverade sprinklers



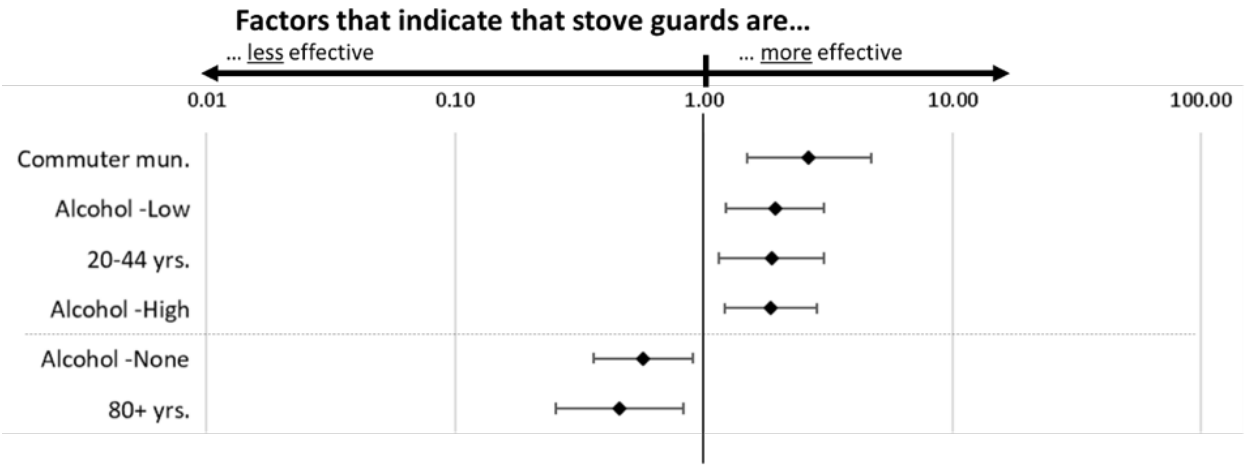
Den viktigaste faktorn är frånvaro av rökning (OR = 7,8; 95% KI, 5,6 - 10,8) vilket sannolikt beror på att bränder som drabbar rökare tenderar att antändas i direkt närhet till offret där denna typ av intervention visat vara för långsam för att förhindra dödsfallet. Värme-aktiverade sprinklersystem är effektivare för yngre människor, i synnerhet 20-44 år (OR = 1,8; 95% KI, 1,1 - 2,9),de som bor i hus (OR = 2,2; 95% KI, 1,6 - 2,9) och mindre effektiva för personer i vårdhem (OR = 0,3; 95% KI, 0,2 - 0,5).

Detektor-aktiverade sprinklers



I likhet med flera andra åtgärder är rökning en stark indikator på effektiviteten (OR = 3,5; 95% KI, 2,8 - 4,3) såväl som att bo ensam (OR = 1,6; 95% KI, 1,3 - 1,9) och i en lägenhet (OR = 2,2; 95% KI, 1,8 - 2,6). Effektiviteten är också högre för de som bor i storstadskommuner (OR = 1,6; 95% KI, 1,2 - 2,2) samt i kommuner med genomsnittlig inkomst (OR = 1,5; 95% KI, 1,2 - 1,8).

Spisskydd



Spisvakter eller spisskydd är mest effektiva för de som bor i pendlarkommuner (OR = 2,6; 95% KI, 1,5 – 4,7) samt hos individer med både låga (OR = 1,9; 95% KI, 1,2 - 3,1) och höga (OR = 1,9; 95% KI , 1,2 - 2,9) alkoholnivåer. Dessutom verkar yngre vuxna, (20-44 år (OR = 1,9; 95% KI, 1,2 - 3,1)) ha större nytta av interventionen. Bland de faktorer som indikerar en lägre effektivitet är frånvaron av alkohol (OR = 0,6; 95% KI, 0,4 - 0,9) samt att vara i den äldsta åldersgruppen, 80+ år (OR = 0,5; 95% KI, 0,3 - 0,8). Det ska dock noteras att den åldersmässiga dimensionen kan vara kopplad till att många äldre personer redan har denna typ av åtgärd installerad och därmed kan bristen på potentiell effektivitet snarare indikera att åtgärden redan finns och är effektiv i denna grupp.

Samhällets preventiva arbete

Sedan 2013 har många av Sveriges kommuner arbetat med individanpassat brandskydd (IAB) enligt den metod som presenteras i vägledningen *Brandsäker bostad för alla - Vägledning för individanpassat brandskydd* från MSB (MSB, 2013), en metod som rör sig över både makro-, meso- och micronivå. I vägledningen beskrivs ett arbetssätt för att rikta det förebyggande arbetet mot riskutsatta personer, det rör sig ofta om äldre personer men även mot andra som av någon anledningar har en ökad risk för att skadas i en bostadsbrand. Det har dock tidigare framkommit att det finns en rad hinder på vägen för ett fungerande arbete med IAB (Jönsson & Gustavsson, 2017). Vi har därför genomfört en studie om räddningstjänstens arbete med IAB och identifierat ett antal faktorer som underlättar respektive står i vägen för en framgångsrik implementering av ett förebyggande arbete för sårbara grupper.

Som typ av intervention har IAB en rad fördelar. Metoden går exempelvis att införa gradvis och den kan lätt modifieras utifrån lokala förutsättningar, vilket också i stor utsträckning görs. Ett av de största hindren kan dock hänföras till utformningen av metoden då det är oklart vem som är ansvarig för brandskydd för utsatta grupper. Det får till följd att det är svårt för organisationer inom kommunen att till fullo ta ansvar för utformning och införande av åtgärder. Vidare uppstår frågan om vem som ska stå för de kostnader som tillkommer och hur resurser ska allokeras i redan ansträngda organisationer, något som speciellt gäller äldreomsorgen och socialtjänsten.

IAB kräver samverkan inom den kommunala organisationen där räddningstjänsten, äldreomsorgen och socialtjänsten är huvudaktörer. Även om insikten om behovet ofta är på plats så är det enligt räddningstjänsten svårt att upparbeta och vidmakthålla samarbetet. Dödsfall till följd av brand i bostad

är en relativt ovanlig företeelse och arbetet med IAB konkurrerar med en rad andra behov som behöver tillgodoses. Denna problematik är inte unik för Sverige, liknande hinder har identifierats i Norge (Halvorsen, Almklov, & Gjøsund, 2017), och våra resultat tyder på ett behov av en djupare förståelse för förutsättningarna inom olika förvaltningar. Framgångsfaktorer verkar vara att i största möjliga mån integrera IAB i befintliga arbetsprocesser. Något som framstår som en avgörande framgångsfaktor är att inom räddningstjänsten ha personer som specifikt arbetar med frågan och som idealt har kompetens från omsorg eller socialtjänst, och på så sätt kan underlätta samarbetet (Kimberly & Evanisko, 1981).

En annan avgörande faktor är rådande organisationskultur i involverade verksamheter. Det preventiva arbetet riktat mot enskilda individer är en relativt ny aktivitet för räddningstjänsten som skiljer sig från deras traditionella roll. Det är inte den primära uppgiften och man upplever sig ha bristande kunskaper inom området. Därför är behovet av stort av att någon går före och visar vägen, något som underlättar för andra att sedan följa. De som varit tidiga med att arbeta med IAB fungerar som goda exempel och andra kan dra nytta av deras lärdomar. När det gäller processen framstår en stegvis implementering vara att föredra. Genom att starta i liten skala kan metoder förankras i verksamheten, vilket bäddar för att de ska fungera även på längre sikt. Gällande vidmakthållandet av arbetssättet är bristen på återkoppling på preventiva åtgärder identifierat som ett betydande hinder och det finns ett behov av att vidareutveckla nyckeltal för att mäta effekten av IAB.

Till sist kan nämnas att ett betydande hinder är målgruppens bristande motivation till åtgärder. När väl riskindivider identifierats är det inte alls säkert att de är intresserade av att vidta de åtgärder som föreslås, en faktor som ofta förbises (Damschroder et al., 2009). Sårbara personer, som är i störst behov av IAB, är ofta marginaliserade med förklaringar i sociala bestämningsfaktorer (Halvorsen et al., 2017). Efter att olika organisatoriska hinder överkommits kvarstår att motivera individen till förändring, en aspekt som behöver undersökas vidare.

Konklusion

I analysen av skadedata utgick vi ifrån hypotesen att det finns specifika karakteristika som utmärker de bränder som drabbar äldre personer. Resultatet visar dock att så inte är fallet. Den tydligaste skillnaden mellan samtliga händelser och de där äldre personer som omkommer är att tekniska fel är aningen vanligare i den förstnämnda.

Det är alltså inte speciella typer av händelser beträffande exempelvis tändkälla, omfattning eller plats som drabbar äldre. Istället verkar det finnas underliggande sårbarhet för alla typhändelser. Antagligen har äldre personer inte ökad risk i relation till sin ålder, utan för att de i större utsträckning har nedsatt förmåga vilket ofta beror på ålder. Ett sätt att tänka kring sårbarhet är att se bortom exempelvis ålder, livssituation eller diagnos, och istället koncentrera sig på vilka konsekvenser det får för förmågan att hantera händelsen och försöka hitta sätt att kompensera för dessa brister.

Vad gäller effektiviteten av förebyggande åtgärder och interventioner så visar resultaten på viktiga och praktiska slutsatser. Trots vissa uppenbara resultat, i synnerhet vad gäller interventioner mot rökare, belyser resultaten vikten av att skräddarsy åtgärder utifrån individen. Detta gäller inte enbart aspekter såsom ålder, kön och rökare/icke rökare utan också boendeförhållanden och kommuntyp. Utifrån dessa resultat bör det vara möjligt att göra det preventiva arbetet betydligt mer effektivt.

I samhällets förebyggande arbete är den största utmaningen oklarheten gällande ansvarsfrågan. Det gör det svårt att allokera de medel och resurser och att göra samordnade insatser. Innan ett förtydligande

gällande ansvar är det antagligen svårt att få ett fullt ut fungerande förebyggande arbete på plats. Ett ytterligare hinder är att arbetet kräver långtgående samverkan mellan de aktörer som kommer i kontakt med riskpersoner. Att identifiera riskpersoner och efter det kunna införa förebyggande åtgärder kräver att de aktörer som kommer i kontakt med riskpersoner samverkar. Den riskutsatta är sällan helt okänd i systemet, men ansvarsfrågan och den strikta uppdelningen av uppdrag försvårar arbetet med att få det förebyggande arbetet på plats.

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Publikationslista för vidare läsning

Här listas tidigare delprojektens samlade publikationer

Framgångsfaktorer vid bostadsbränder av Finn Nilson, Marcus Runefors, Frida Vermina Lundström, Carl Bonander och Håkan Frantzich https://www.brandforsk.se/forskningsprojekt/2017/framgangsfaktorer-vid-bostadsbrander/

Bostadsbränder och äldre personer av Finn Nilson, Carl Bonander, Marcus Runefors, Lotta Vylund och Linnea Lundgren https://www.brandforsk.se/forskningsprojekt/2019/bostadsbrander-och-aldre-personer/

Nilson, F., & Bonander, C. (2020a). Household Fire Protection Practices in Relation to Socio-demographic Characteristics: Evidence from a Swedish National Survey. Fire Technology, 56(3), 1077-1098. doi:10.1007/s10694-019-00921-w

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Förutom dessa är även artiklarna i denna rapports bilagor till listan.

Bilaga 1. Fördjupad problembeskrivning och analys av åtgärder (AP1)

Residential Fire Fatality Typologies in Sweden: Results after 20 years of High-Quality Data

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Abstract

The reduction of residential fire mortality rates has, after several decades of rapid reductions, during the last decades flattened out. In order to further reduce rates, more knowledge is required concerning the causes and typologies of fatal residential fires in order to improve preventative efforts. Previous studies have shown that fatal residential fires can be grouped into six categories. However, the analyses were performed on a limited dataset meaning that there were some uncertainties regarding the robustness of the analyses. Also, the particularly vulnerable group of older persons could not be analysed separately. As such, this study re-analysis the typologies for fatal residential fires in Sweden using cluster analysis, including data for a period of 20 years. The results suggest that the original cluster analyses were relatively robust for both the total population and for the elderly thereby indicating that fatal fire seem to be consistently grouped into certain types. As such, preventative efforts can specifically be directed towards these types of events involving identified individuals. The results also suggest that the number of fatal residential fires with unknown causes have increased in relation to other fires during the 20-year study period. Fatal residential fires with unknown causes are shown to be more often large night-time fires occurring in houses in rural locations suggesting that rescue services may need to re-evaluate both prevention and reactive strategies and organisations.

Introduction

Although large risk reductions in fire-related deaths have been observed in most high-income countries during the last 50-60 years (Administration, 2011), the downward trend of residential fatal fire rates has largely tapered off in countries such as Sweden (Jonsson, Runefors, Särdqvist, & Nilson, 2016) and household fires are still a considerable societal problem in many countries (Haagsma et al., 2016; Murray et al., 2012). In an attempt to improve societies prevention efforts, an increased knowledge concerning the underlying risk factors is critical. Previous studies have shown that elderly people, those physically and mentally challenged, and people with drug and alcohol abuse suffer from a substantially increased risk of dying in fire (Turner et al., 2017; Warda, Tenenbein, & Moffatt, 1999). However, merely indicating a higher risk amongst relatively large crudely defined groups of individuals, is of limited use when attempting to improve societal preventative efforts. As such, in order to more precisely find individuals or situations that are particularly high-risk, more complex analyses are required.

In a previous study we performed a cluster analysis on Swedish fire fatality data between 1999 and 2007 by using multiple correspondence analysis (MCA) with agglomerative hierarchical clustering (AHC) to study common fire-related mortality typologies (Jonsson et al., 2017). In the study we could show that fatal fires could be grouped into one of six categories;

(1) fatalities that were more often elderly people, usually female, whose clothes were ignited (17% of the sample);

(2) middle-aged (45–64 years old), (often) intoxicated men, where the fire usually originated in furniture (30%);

(3) fires caused by technical fault, started in electrical installations in single houses (13%);

(4) fires caused by cooking appliances that had been left on (8%);

(5) events with unknown cause, room and object of origin (25%); and

(6) deliberately set fires (7%).

Theoretically, using these clusters based on both fire- and person-based data, it could be possible to find specific prevention interventions for specific clusters. However, whilst the clusters gave important information and can be helpful in analysing potential prevention measures, two unanswered research questions evolved from the results. Firstly, one of the larger clusters (accounting for 25% of all cases) was a cluster based on a lack of data regarding the fire. Given the relatively large percentage, had better data been available, the “missing data” cases could be either evenly or unevenly distributed between the clusters or, alternatively, the cluster actually represented a unique type of fatal fire that failed to be identified. In the previous article, we encouraged improved data collection in order to improve the analysis (Jonsson et al., 2017) and to ascertain if these cases were representative for the entire sample or differed.

Secondly, the analyses were performed on the entire population of fatal fires. Predominantly, this was due to the fact that the dataset (despite including 8 years of data) was relatively small and dividing it into smaller datasets could have produced skewed or faulty results. Also, it is preferred that no categorization of the data should be done prior to using the MCA with AHC (ref). However, in the case of fire fatalities, given that it is well-known that fire mortality is strongly differentiated by age groups (Hasofer & Thomas,

2006; Jennings, 2013; Jonsson et al., 2017), it could be argued that performing age-based cluster analyses could be beneficial in order to specify preventative interventions towards elderly.

Consequentially, this study has two aims. The first aim is to update the clustering of fire fatalities in Sweden using data for 20 years. Given the increased dataset, this study will also age-differentiate and perform clustering on both the total population as well as the older population (over 65 years) and the younger population (64 years and under). Lastly, the study aims to analyse the cases with missing data in order to investigate if the proportion has changed and how these cases differ to the "known data" cases and if this might skew the results.

Materials and Method

Materials

The dataset used for this study is a subset of a compiled database using linked individual- and event-level data from three different data sources covering all fatal fires in Sweden between January 1st, 1999 and December 31st, 2018. Included in this study are all recorded fire fatalities in residential occupancies where victims died within 30 days as a direct effect of a fire or explosive combustion process. Indirect fatalities, where the victim died from, for example, falling structural members or jumping to safety, are not included.

In order to include different aspects of both the event and individual, the dataset is compiled by combining several different databases, predominantly by using the highly reliable (Ludvigsson, Otterblad-Olausson, Pettersson, & Ekbom, 2009) Swedish Personal Identification Number (PIN). As such, the database on fatal fires, held by the Swedish Civil Contingencies Agency (MSB) and the database on forensic examinations, held by the National Board of Forensic Medicine could be combined into one dataset. For further details regarding the data, matching methods, and compilation of the linked database, see (Jonsson, Bergqvist, & Andersson, 2015).

The final dataset contains data on both individual and event levels. At the event-level, the following variables were included: date, time of day, municipality, residential category, cause of fire, object of origin and room of origin. On the individual-level, gender, age at death, primary injury diagnosis, blood alcohol concentration (BAC‰) and carboxyhemoglobin (COHb%) were included. By linking rescue service reports to the events, fire size on rescue service arrival and fire spread could be included. For further information on the particularities of the dataset, see (Jonsson et al., 2017).

Data analysis

Cluster Analysis

Using both event and individual variables a cluster analysis was performed by using multiple correspondence analysis (MCA) with agglomerative hierarchical clustering (AHC) to study common fire-related mortality typologies. MCA with AHC is a generalisation of standard multivariate cluster analysis techniques for categorical datasets and is a method that effectively summarises and presents large sets of variables into a much smaller set of principal components, or clusters (Husson, Lê, & Pagès, 2010), thereby assisting the practical understanding of the data as well as identifying underlying connections.

Using MCA with AHC, variables can either be chosen to be a variable that can influence the estimation of clusters (active variables) or as a variable that merely supports the interpretation (supplementary

variables). Given the study's aim of updating the previous study (Jonsson et al., 2017), the same eight active variables were included. These were variables that were deemed relevant to describe the circumstances of the event, the involved individuals as well as being relevant from a prevention perspective. These were: residential category, cause of fire, room and object of origin, age group, gender, presence of alcohol in blood, and primary injury diagnosis. Other variables were included as supplementary variables. The active and supplementary variables used in the cluster analysis and their categories, are detailed in Table A1, in Appendix 1.

In terms of the cluster analysis and determining the optimal number of clusters that best summarise the data, the method described by Husson et al (2010) was used. I.e., an automatic partitioning algorithm is used that first partitions the data from a hierarchical tree, selecting the optimal number of clusters based on the relative inertia gain from each new cluster, then consolidates and improves the accuracy of the selection using a K-means algorithm consisting of two parts. Following this automated process, the clusters must be interpreted in order to identify the specific aspects distinguishing the clusters from each other. This is done using multivariate significance tests of the difference between the clustered categories to the sample average of those categories. The same process, using the same variables was performed when the dataset was divided into an older population (65 years and above) and a younger population (64 years and below).

Cases with Missing Data

The second aim of this study is to investigate the cases with missing data. This was accomplished in three steps. Firstly, the development over time of the number of cases with missing data was plotted to assess whether improvements had occurred following the encouragement in our previous study. Secondly, the cases with missing data were compared to the cases with data using odds-ratios (OR) in order to assess whether they differed significantly and as such determine whether the cases with missing data were likely to be similar or whether they were representable of the entire dataset. Since significance test were performed on a number of variables, the significance levels were corrected for the number of independent tests (k =108) using Bonferroni correction (Weisstein, 2004). Thirdly, a cluster analysis, in line with the description above, was performed using only the known data in order to test whether new clusters appeared.

P-values < 0.05 were considered as statistically significant. The cluster analysis was performed using R with the 'FactoMineR' package (Lê, Josse, & Husson, 2008).

Results

In terms of clustering all fatal fire in Sweden between 1999 and 2018, six clusters were identified with the statistically significant attributes described below in text and in appendix A2;

7. Fatalities due to the ignition of clothes either by candles or cigarettes (246 cases, 13% of the sample). Victims were more likely to be older women who died of burns and who were not affected by alcohol though had consumed anti-depressants. The fires, were small, occurred in care homes in smaller, rural communities during the day and during the winter months.
8. Fatalities due to furniture being ignited by cigarettes (513 cases, 28% of the sample). Victims were most often between 45 and 79 years old, lived alone and were affected by alcohol. Fires

occurred most often in apartments in medium-sized municipalities where beds, chairs of sofas were ignited.

9. Fires caused by technical faults, (272 cases, 15% of the sample). No age- or sex-specific group are particular victims in this cluster. However, compared to the average, the fires more often occurred in houses and caused multiple deaths, predominantly due to toxic gases. The fires were caused by technical faults or heat transfer.
10. Fires caused by cooking appliances that had been left on (118 cases, 6% of the sample). Victims were more likely to be 45-64 years old, lived in apartments and died of toxic effects. Alcohol as well as sedatives were often involved and the fires occurred more often at night during weekends.
11. Deliberately set fires (140 cases, 8% of the samples). Victims were more often between 20-64 years or 0-4 years and more often male. Alcohol was more rarely involved whilst illegal drugs were more often involved. Often, flammable liquids were the fire cause.
12. Events with unknown causes (567 cases, 31% of the sample). These fires occurred more often in houses and the victims were between 45 and 79 years. The fires were more often large, occurred more often at night, in rural settings and during the winter.

Given the 20-year study period, it is possible to assess how the relative relationship between the clusters has changed over time. As is seen in figure 1, the trend during the 20 years is that the proportion of fatal fires with unknown causes has increased, largely as a consequence of a relative reduction of clusters 1-3.

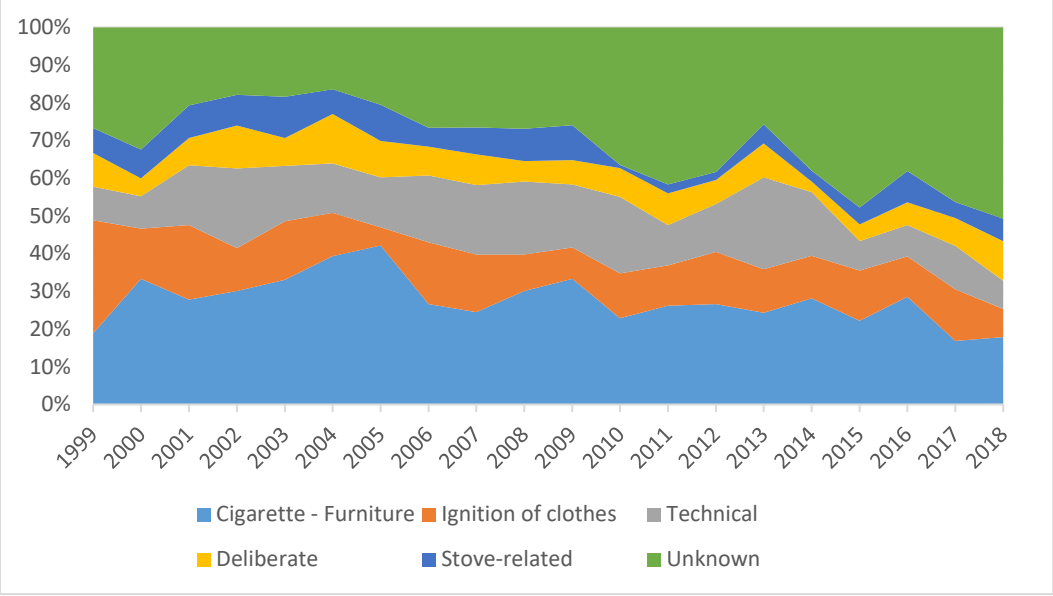

Figure 1. The relative distribution of fatal fire clusters for the total population between 1999 and 2018 (three-year average)

Given the overrepresentation of elderly in fatal fires, as well as the advantage of having a large dataset, the second aim of this study was to perform a cluster analysis merely on those 65 years and above in order to ascertain whether specific types of fires are more common in this population. In similarity to the total population, six clusters were identified. In many respects these were similar to those described

above albeit with slight differences in regards to the statistically significant attributes. The clusters are described below in text and in appendix A3;

1. Fatalities due to the ignition of clothes either by candles or cigarettes (189 cases, 19% of the sample). As in the total population, victims were more likely to be older women who died of burns and who were not affected by alcohol though had consumed anti-depressants. The fires, that were small and occurred in care homes in smaller, rural communities during the day and during the winter months.

2. Fatalities due to furniture being ignited by cigarettes (254 cases, 26% of the sample). This cluster was also very similar to the one identified in the total population. Victims were most often between 65 and 79 years old, lived alone and were affected by alcohol. Fires occurred most often in apartments in medium-sized municipalities where beds, chairs of sofas were ignited.

3. Fires caused by technical faults, (72 cases, 7% of the sample). Victims were more likely to be 90 years or older, living in larger cities and died of toxic effects. Compared to the average, the fires were more often caused by technical faults or heat transfer in relation to electrical equipment.

4. Fires caused by cooking appliances that had been left on (49 cases, 5% of the sample). Victims were more likely to be 64-69 years old and died of toxic effects. Victims were more often affected by alcohol as well as sedatives and anti-depressants.

5. Deliberately set fires and fires related to fireplaces/hearths (114 cases, 12% of the samples). This cluster includes both deliberately set fires though also fires related to fireplaces and hearths. The common traits were that victims were more often between 70-79 years and more often male. The fires also more often occurred in a house in rural to semi-urban areas and the starting point was not in a regular room. The fires were often relatively large and occurred during the day.

6. Events with unknown causes (295 cases, 30% of the sample). These fires were characterised by large amounts of unknown data. No age- or sex-specific group were overrepresented however the fires were more often large and had occurred more often at night, in houses in rural settings and during the winter.

As is seen above, the clusters differ very slightly from the total population in terms of the identified clusters. The distribution between the clusters is also relatively similar with the notable differences being that the cluster “fatalities due to the ignition of clothes either by candles or cigarettes” accounts for a larger proportion and “fires caused by technical faults” accounts for a smaller proportion in comparison with the total population. In similarity to the total population, the development over time clearly shows an increase of the fatal fires with unknown causes (figure 2). A visual comparison would suggest that the decreases are most seen in cluster 1, 4 and 5.

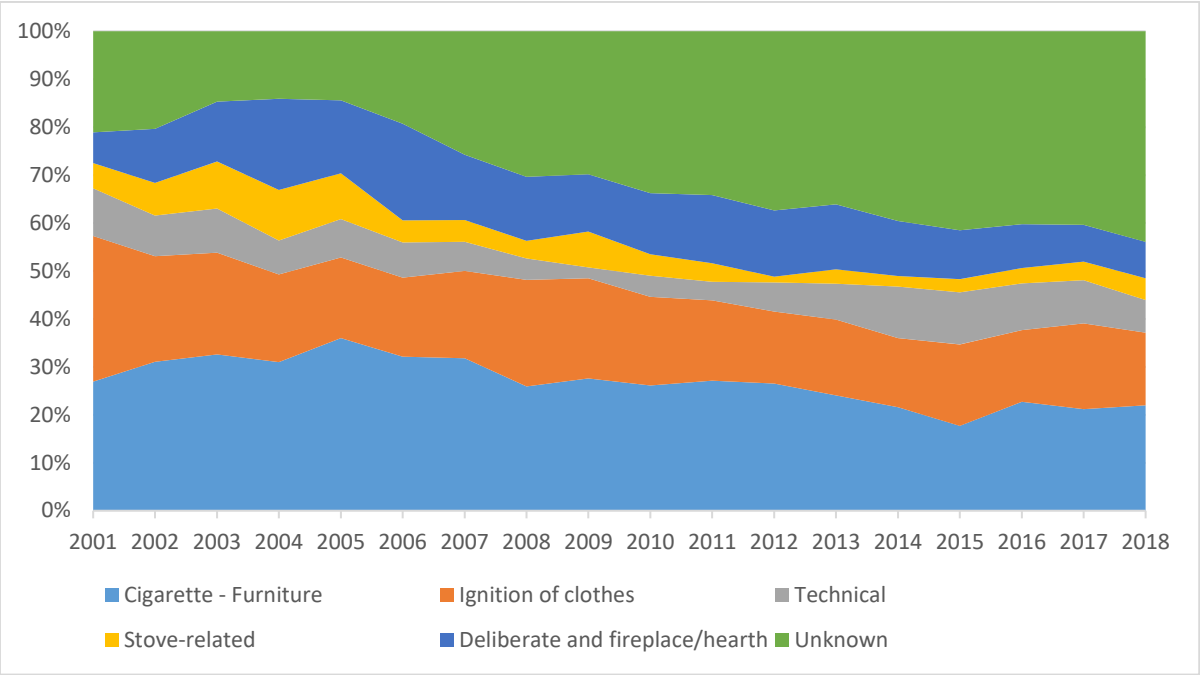

Figure 2. The relative distribution of fatal fire clusters for the elderly population (65 years and above) between 1999 and 2018 (three-year average)

From a fire prevention, as well as a methodological, perspective it is clearly problematic that such a large group is defined as unknown. Similarly, including deliberately set fires can also mean that identifying clusters at which preventative measures can be aimed is more difficult. As such, the clustering was repeated for the elderly population but excluding unknown causes and deliberately set fires. This resulted in five clusters that are very similar to those described above (more details are found in appendix A4).

1. Fatalities due to the ignition of clothes either by candles or cigarettes (185 cases, 32% of the sample).
2. Fatalities due to furniture being ignited by cigarettes (199 cases, 34% of the sample).
3. Fires caused by technical faults, (56 cases, 10% of the sample).
4. Fires related to fireplaces/hearths (96 cases, 16% of the samples)
5. Fires caused by cooking appliances that had been left on (48 cases, 8% of the sample).

Given that the removal of deliberate and unknown fires produced very similar clusters to the previous models, this would suggest that the clusters are stable and robust. However, given the large number of fatal fires with unknown causes, as well as the relative increase of these fires in the dataset over time, the final important step was to compare all fatal fires with known causes with all fatal fires with unknown causes in order to identify potential characteristics in the unknown cluster that could be beneficial for prevention. Table A5 shows all results whilst figure 3 shows the resulting significant variables.

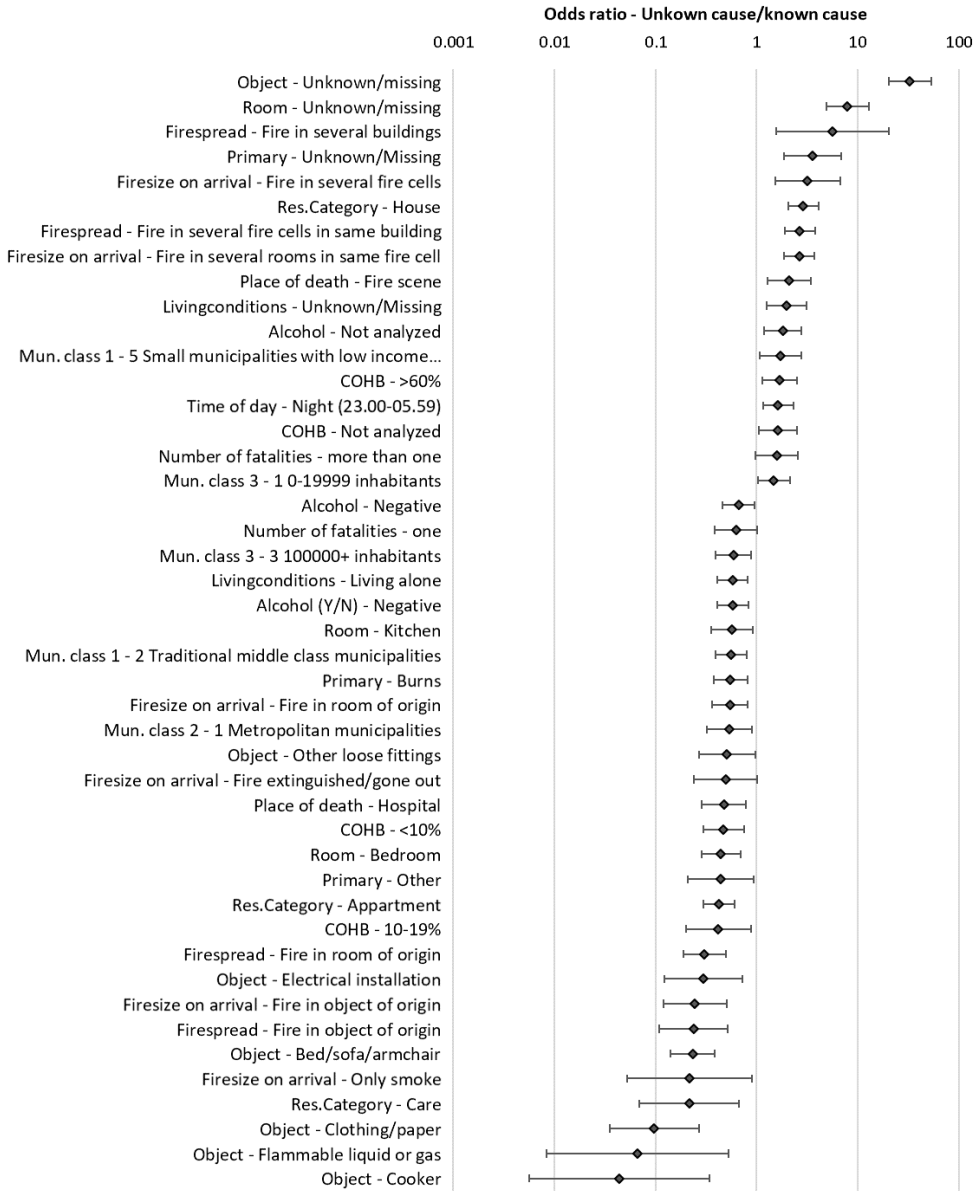

Figure 3. Significant odd-ratios for known/unknown causes

As is clear from figure 3, a number of significant differences exist between fatal fires with known and unknown causes. Most notably, fatal fires with unknown causes are more often night-time fires, involve multiple victims are larger than known fires and involve several fire cells and/or buildings. They also occur more often in houses in rural areas distinguished by small municipalities with low income and low education and the victims more often die at the scene. Interestingly, however, no specific age or sex of the victims are overrepresented.

Discussion

This study can show a number of interesting results. Most importantly, the clusters found in our original paper are still, despite a considerably larger dataset, largely the same. Also, when smaller datasets were analysed, i.e. elderly and elderly without unknown and deliberate causes, the clusters remained

practically the same. This would indicate that the causes of fatal fires most likely, at least in Sweden, can be clustered into six predominant clusters, mirroring results using other methods in the USA (Ahrens, 2015). Consequentially, therefore, it can comfortably be determined that prevention measures should be aimed towards these clusters. The robustness of the clusters also show that relatively small datasets are sufficient for identifying clusters.

Also clear from this study is that in similarity to other countries (Hall, 2010; Holborn, Nolan, & Golt, 2003), the ignition of clothing, mattresses and furniture due to cigarettes is still one of the most prominent known causes of fatal fires accounting for 41% of all fatal fires in the total population and 45% in the elderly population. Whilst attempts at preventing these fires have been made with the introduction of reduced-ignition propensity cigarettes, these have had a limited effect on reducing fatal fires (C. Bonander, Jakobsson, & Nilson, 2017; C. M. Bonander, Jonsson, & Nilson, 2015).

Although smoking-related causes are still the largest cause of fatal fires in Sweden, in the total population as well as amongst elderly, there does seem to have occurred a relative reduction during the 20-year period. Most likely this is due to the decrease in smokers in Sweden (Stegmayr, Eliasson, & Rodu, 2005) with previous studies showing correlations between the number of smokers in a population and the relative risk of smoking-related fatal fires (Diekman, Ballesteros, Berger, Caraballo, & Kegler, 2008; Kegler, Dellinger, Ballesteros, & Tsai, 2018). Consequentially, if the decrease in smokers continues, it is likely that the proportion of fatal fires being caused by cigarettes will decrease henceforth.

In terms of the non-cigarette clusters there are some other interesting results. For example, in terms of fatal fires caused by cooking appliances that had been left on, this cluster was the smallest amongst elderly, accounting for 5% of the cases. In the total population, these cases accounted for 6% of all fatal fires. These proportions are considerably smaller compared to for example the US where 21% of all residential fatal fires are caused by cooking-related activities (Ahrens, 2019) and 14% in London, UK (Holborn et al., 2003). A number of technological solutions are available for reducing the risks of fatal fires due to cooking appliances (see (Yépez & Ko, 2020) for details) and Sweden has been highly proactive in free-of-charge installing stove timers in the homes of elderly, in particular for those with cognitive disabilities (Nygård, Starkhammar, & Lilja, 2008). Given the differences compared to other countries, Sweden may have been relatively successful with this strategy. However, great caution needs to be taken when comparing fatality rates between countries as both collection methods and inclusion criteria may vary.

The most notable result from the cluster analysis, however, is the fact that the largest cluster was fatal fires with unknown causes and that these fires seem to have increased in relation to other fatal fires during the studied time-period. At face value the fact that the cause of the fires is unknown is disconcerting given the importance of understanding underlying causes in order to find appropriate preventative interventions (M Runefors et al., 2016). However, although the fire cause is unknown, when compared to fires in which the cause was known, a number of interesting results were seen. Specifically, these were large fires with considerable damage leading to several fatalities. The fires were also more often in houses in sparsely populated areas and were more common at night. As such, whilst these fatal fires were clustered around the fact that there was considerable missing data, they are obviously a particular type of fire and differ considerably to other fatal fires.

The fact that the cause of fire is unknown is indicative of the fact that these are fires with massive damage and little for the accident investigators to assess. Obviously, an increase in fatal fires with

unknown causes could indicate a worsening of the quality of the accident investigations, either as a result of time-restraints, economic means or competency amongst the investigators. Likewise, the relative increase of unknown causes could be indicative of a decrease in other causes. However, the results could also indicate that large house fires, often in rural areas at night, are becoming more important targets for fire prevention in Sweden.

Although we would encourage Swedish actors in improving resources and education to accident investigators in order to improve the data, given that no known causes to these fires currently exist, prevention needs to be adapted to the current data. Specifically, the fact that these types of fires are more prevalent in rural settings is cohesive with previous studies showing considerable differences both in regards to societal protection and individual vulnerability in rural areas in Sweden (F Nilson & C. Bonander, 2020). Rescue services in Sweden are municipal-based and given the demographic shift with increased polarisation between urban and rural areas (Smas, 2018) this urbanisation pattern has a dramatic effect on the financial status of rural municipalities (Lindblad, Tynelius, Danell, Pichler, & Anderstig, 2015), meaning that rural communities are therefore more likely to be forced into cost-cutting. Also, as there have been general reductions in the number of attended fires, questions regarding the cost-effectiveness of maintaining full-time municipal rescue services have been raised (see for example (Knight, 2013)). As such, it has been argued that more expensive full-time organisations could be replaced with part-time organisations. However, this will likely lengthen the highly important response times (Jaldell, 2015). Given the relative increase of these very large fatal fires that leave little to investigate, the question must be raised whether changes to the ability and response times of municipal rescue services have inadvertently increased certain types of fires.

However, as raised in a previous paper (F Nilson & C. Bonander, 2020), although societal protection is important in preventing fatal fires, the individual vulnerability and responsibility cannot be ignored. There is evidence that the presence of smoke alarms can compensate for slower response times (Clare, Jennings, & Garis, 2018) and it could be hypothesised that such interventions could be useful in these cases. Smoke alarms are generally only ineffective in situations where individuals are alone or functionally, physically or cognitively disabled meaning that they cannot respond to the signal. Given that there are no indications of an increased use of alcohol, higher age or individuals living alone in the unknown cause cluster, it would seem plausible that smoke alarms could be effective. As such, it could be argued that prevention interventions consisting amongst else of recommendations to use smoke alarms should be directed towards rural homes where response times are known to be longer and where neighbours can have difficulty in noticing fires at night.

Despite comprehensive efforts in reducing the number of limitations in this study, there are some worthy of mentioning. Firstly, alcohol is a known risk factor for fatal fires (Ballard, Koepsell, & Rivara, 1992). However, alcohol is also only present in the body during a limited time-period with much of the alcohol having metabolised within a day (Cederbaum, 2012). As such, whilst alcohol levels in the blood are possible to assess in victims who died at the scene or very shortly afterwards, among those who died several days later in hospital alcohol levels are not possible to ascertain. As such, for those fires in which fatalities generally occurred later and in hospital, it is not possible to assess whether the victims were under the influence of alcohol nor medication. It is therefore reasonable to assume that there is an underreporting of alcohol and medication/drugs amongst fires in which fatalities occurred later. Another important limitation is that the authors of this study have had no input or impact on the collected data. Therefore, the dataset is compiled by a variety of professionals with unknown competency or

techniques. Standard procedures can vary and individual professionals or organisations are free to make choices concerning the accident investigations. As such, some data (for example in regards to the presence of different medications or drugs) will not be collected due to individual assessments. Whilst we have no indications that these assessments are anything but randomly distributed in the dataset, this cannot be completely disregarded.

Conclusions

This study raises a number of important aspects in terms of fatal residential fires. Firstly, it would seem that, at least in Sweden, residential fatal fires are consistently clustered into six distinct clusters. Despite a longer time-series this study produces very similar results to our previous study. Also, when further changes were made to the dataset by focusing on vulnerable groups or only including known accidental causes, the clusters were largely unchanged. Therefore, the results in this study indicate that the clusters are relatively stable over time. As such, for countries who have yet compiled datasets similar to the dataset used in this study, it may require considerably fewer number of years of data in order to perform the same analyses.

In terms of the transferability of the results in this study to other countries, this cannot be ascertained. Therefore, we encourage other studies using similar methods in order to make international comparisons. However, before such studies have been performed we would suggest that given the similarity between these clusters and results in countries of similar development and culture, it is likely that similar clusters will be seen in similar countries, albeit in different proportions. As such, we would encourage preventative efforts to focus on the clusters shown in this study in order to further reduce the number of fatal residential fires.

Finally, it is problematic that almost a third of all fatal fires in Sweden have unknown causes and little information regarding the victims. Parallel to actively working with preventative measures aimed at the identified clusters, improvements must be made in terms of the accident analyses of fatal fires in order to identify prevention measures.

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Appendix

Table A4. Odds-ratio (OR) for unknown causes of fire (case) relative to all other causes (control).

Variable	Value	Odds-ratio (OR)
Age group	1. 0-4	1.28 (0.27-6.03)
	2. 5-19	0.61 (0.19-1.9)
	3. 20-44	1.02 (0.62-1.69)
	4. 45-64	1.15 (0.8-1.65)
	5. 65-79	1.04 (0.72-1.5)
	6. 80+	0.84 (0.56-1.25)
Gender	Female	0.78 (0.55-1.1)
	Male	1.29 (0.91-1.82)
Primary	**Burns**	**0.55** (0.38-0.81)**
	Toxic effects	1.38 (0.98-1.93)
	Other	**0.44** (0.21-0.94)**
	Unknown/Missing	**3.57** (1.87-6.82)**
Alcohol	1. 0.1-0.99	1.17 (0.59-2.32)
	2. 1.0-1.99	1.39 (0.81-2.37)
	3. 2-2.99	1.09 (0.67-1.76)
	4. 3-	0.95 (0.49-1.83)
	Negativ	**0.67** (0.46-0.96)**
	Not analyzed	1.22 (0.84-1.76)
Residential Category	**Appartment**	**0.42** (0.3-0.6)**
	Care	**0.22** (0.07-0.67)**
	House	**2.91** (2.05-4.14)**
Object	**Bed/sofa/armchair**	**0.23** (0.14-0.39)**
	Other loose fittings	**0.51* (0.27-0.97)**
	Clothing/paper	**0.1** (0.04-0.27)**

	Cooker	**0.04** (0.01-0.34)**
	Electrical installation	**0.3** (0.12-0.72)**
	Flammable liquid or gas	**0.07** (0.01-0.53)**
	Smoke duct. fire place	0.39 (0.09-1.71)
	Other	0.54 (0.23-1.24)
	Unknown/missing	**32.95** (20.31-53.46)**
Room	**Bedroom**	**0.44** (0.29-0.69)**
	Kitchen	**0.57** (0.36-0.91)**
	Living room	0.7 (0.47-1.04)
	Other	0.8 (0.49-1.3)
	Unknown/missing	**7.98** (4.9-12.99)**
Municipality	1 Municipalities with high income. high education	1.13 (0.61-2.12)
class1	**2 Traditional middle class municipalities**	**0.56** (0.4-0.79)**
	3 Municipalities with tourism-related economy	1.35 (0.88-2.09)
	4 Municipalities with traditional industries	1.13 (0.74-1.74)
	5 Small municipalities with low income. low education and neg population growth	**1.73** (1.07-2.78)**
Municipality	**1 Metropolitan municipalities**	**0.54** (0.32-0.89)**
class2	2 Suburban municipalities	0.93 (0.55-1.56)
	3 Large cities	0.88 (0.59-1.31)
	4 Suburban municipalities to large cities	1.01 (0.41-2.49)
	5 Commuter municipalities	1.02 (0.55-1.9)
	6 Tourism and travel industry municipalities	1.68 (0.8-3.52)
	7 Manufacturing municipalities	1.02 (0.62-1.66)
	8 Sparsely populated municipalities	2.13 (0.92-4.93)
	9 Municipalities in densely populated regions	1.24 (0.72-2.14)
	10 Municipalities in sparsely populated regions	1.63 (0.77-3.47)
Municipality	**1 0-19999 inhabitants**	**1.48** (1.03-2.13)**

class3	2 20000-99999 inhabitants	1.06 (0.75-1.48)
	3 100000+ inhabitants	**0.59** (0.4-0.89)**
Season	Winter	1.17 (0.84-1.64)
	Spring	0.89 (0.56-1.4)
	Summer	0.86 (0.52-1.4)
	Autumn	0.97 (0.65-1.45)
Day and time	Weekday-daytime	0.73 (0.52-1.05)
	Weekday-nighttime	1.34 (0.91-1.98)
	Weekday-unknown time	0.66 (0.21-2.11)
	Weekend-daytime	0.79 (0.52-1.22)
	Weekend-nighttime	1.4 (0.89-2.21)
	Weekend-unknown time	2.86 (0.47-17.53)
	Unknown	4 (0.36-44.85)
Firesize on arrival	**Fire extinguished/gone out**	**0.5* (0.24-1.01)**
	Only smoke	**0.22** (0.05-0.89)**
	Fire in object of origin	**0.25** (0.12-0.51)**
	Fire in room of origin	**0.54** (0.36-0.82)**
	Fire in several rooms in same fire cell	**2.65** (1.87-3.74)**
	Fire in several fire cells	**3.2** (1.52-6.7)**
	Unkown/Missing	0.95 (0.45-1.99)
Firespread	**Fire in object of origin**	**0.24** (0.11-0.52)**
	Fire in room of origin	**0.31** (0.19-0.5)**
	Fire in several rooms in same fire cell	1.01 (0.67-1.54)
	Fire in several fire cells in same building	**2.69** (1.89-3.82)**
	Fire in several buildings	**5.66** (1.58-20.31)**
	Unknown/missing	1.07 (0.62-1.87)
Weekday	Monday	0.92 (0.54-1.58)
	Tuesday	1.02 (0.62-1.68)

	Wednesday	1.12 (0.67-1.88)
	Thursday	0.69 (0.42-1.14)
	Friday	1.18 (0.74-1.87)
	Saturday	1.14 (0.74-1.77)
	Sunday	0.98 (0.63-1.52)
Time of day	Morning (06.00-08.59)	0.86 (0.51-1.44)
	Forenoon (09.00-12.59)	0.66 (0.38-1.13)
	Afternoon (13.00-17.59)	0.81 (0.51-1.3)
	Evening (18.00-22.59)	0.81 (0.54-1.23)
	Night (23.00-05.59)	**1.64** (1.16-2.33)**
	Unknown	1.23 (0.52-2.87)
Number of fatalities	more than one	1.59* (0.98-2.58)
	one	0.63* (0.39-1.02)
Alcohol	Positive	1.15 (0.82-1.63)
	Negative	**0.58** (0.41-0.82)**
	Not analyzed	**1.82** (1.2-2.77)**
COHB	**1. <10%**	**0.47** (0.3-0.76)**
	2. 10-19%	**0.42** (0.2-0.87)**
	3. 20-29%	1.01 (0.45-2.24)
	4. 30-39%	1.08 (0.55-2.11)
	5. 40-49%	1.05 (0.58-1.89)
	6. 50-59%	0.9 (0.55-1.49)
	7. >60%	**1.69** (1.14-2.51)**
	Not analyzed	**1.62** (1.05-2.5)**
Place of death	**Fire scene**	**2.11** (1.28-3.46)**
	Hospital	**0.47** (0.29-0.78)**
Livingconditions	Family	1.21 (0.82-1.8)
	Living alone	**0.58** (0.41-0.82)**

	Unknown/Missing	**1.99** (1.27-3.11)**
Drugs-Sedativ	Yes	0.72 (0.46-1.12)
	Unknown	1.39 (0.89-2.17)
Drugs-Antidep	Yes	0.73 (0.44-1.21)
	Unknown	1.37 (0.83-2.27)
Drugs-Illegal	Yes	1.58 (0.66-3.8)
	Unknown	0.63 (0.26-1.51)

Bilaga 2. Effektiva åtgärder (AP2)

The Influence of Sociodemographic Factors on the Theoretical Effectiveness of Fire Prevention Interventions on Fatal Residential Fires

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Abstract

The risk of fatal residential fires is known to be differentiated by sociodemographic factors. However, often prevention measures are introduced generally in a population thereby perhaps affecting the effectiveness of these interventions. By using a 20-year high-quality register over fatal fires in Sweden and a previously validated Boolean expressions regarding the effectiveness for specific interventions, this study investigates the theoretical effectiveness of fire interventions in relation to different sociodemographic variables and fatal residential fires. The results show that the effectiveness of different fire-related prevention measures varies considerably in relation to different sociodemographic variables such as age, sex, municipal characteristics and living conditions. As such, the paper highlights the importance of matching the correct fire prevention measure to each individual depending upon sociodemographic risk factors in order to achieve maximal effectiveness.

Keywords

Smoke alarms; Living conditions; Fire prevention; Sweden

Background

Despite considerable differences between countries [1, 2] and within countries [3] and the positive trend in the last half-decade [4], residential fire fatalities and associated injuries remain a major problem worldwide. In an attempt to further reduce rates and absolute numbers, a number of different societal and individual interventions have been introduced. Primarily, focus has been on smoke alarm installations, education or multi-facetted programs and these have been introduced widely with the expectation of preventing one or more of the five steps in the fire process; reducing heat; stopping the ignition of the first object; hindering fire growth; initiating evacuation; and completing evacuation [5]. Whilst these interventions have often shown an effect [6-9], other interventions, such as campaigns [10] and insurance-related incentives [11] as well as legal changes to cigarettes [12] and upholstery [13] have shown varied effectiveness.

Whilst the reason for the varied results regarding certain interventions could be methodological or technical, it could also be that the effect differs depending upon the group that receives the intervention. Specifically, although safety interventions can be evaluated on a general, national or local level, it is widely known that fire mortality is distinctly affected by sociodemographic factors [14]. Returning to the five points in the fire process [5], it can be presumed that the overrepresentation of certain subgroups in term of the risk of fire mortality is due to sociodemographic factors affecting one or several of these points. Consequentially, preventative measures must be correctly matched with individuals who lack the certain capabilities, thereby needing help to compensate for this factor. For example, a fire alarm is designed to assist in initiating evacuation. Whilst such an intervention will likely be effective for able-bodied and cognitively-sound individuals, the effectiveness is likely to be considerably less for those with physical and cognitive disabilities. Groups that are known to be at higher risk for fire mortality [15, 16]. Therefore, the same intervention will have radically different effects for different individuals or groups [17], not least considering that certain groups have been shown to have a high risk of residential fire though low risk of fire mortality [18]. Put simply, it could be that certain interventions will be more effective to implement for certain sociodemographic sub-groups as the safety intervention compensates a factor that the individual lacks. As such, it is also possible to ascertain which intervention should be recommended to which individual.

Given the comprehensive data concerning fire fatalities in Sweden during the last 20 years [19], a previous study has indicated that the theoretical effect of interventions can be assessed [5]. However, in the previous study, the database consisted of relatively few cases meaning that relatively few sociodemographic variables could be included given the inherent uncertainty. Now, given that the Swedish fire fatality database has been improved and extended, more precise analyses are possible. Therefore, this article aims to assess the theoretical effectiveness of fire interventions in relation to sociodemographic variables.

Method

Data

The dataset used for this study included all fatal fires that occurred in residential occupancies (including care homes) in Sweden between January 1st, 1999 and December 31st, 2018. To be included in the dataset, the death was required to have occurred within 30 days and as a direct effect of a fire or

explosive combustion process. Indirect fatalities, where the victim died from, for example, falling structural members or jumping to safety, were not included. The causality of the fire injury and the fatality is assessed by a forensic pathologist through an autopsy which is common procedure for all unexpected deaths in Sweden.

The identification of cases was based on a combination of the database maintained by the National Board of Forensic Medicine called “Rättsbase” and a database on fatal fires maintained by the Swedish Civil Contingencies Agency which in turn is based on reports from Swedish rescue services and police. The matching is primarily based on the Personal Identification Number (PIN) which is a highly reliable [20] identification number given to all Swedish residents regardless of citizenship. In cases where a PIN-number was lacking in either of the databases, the matching was based on city and date of fire. For further details of the matching procedure, see [19]. This resulted in a total of 1856 fatalities during the studied period.

Cases where the cause, object of origin or room of origin was unknown in the fatal fire database, were matched with the incident reports which are typically filled out in over 99% of the fires [21] where the rescue services responded. For these cases, both the categorical variables and the free-text-fields was examined to investigate if a probable cause, object or room could be determined.

The compiled database composed of a large number of variables regarding both the fire and the individual as well as results from post-mortem blood analysis and the type of municipality. A full list of included variables is available in appendix A.

Data analysis

To assess the theoretical effectiveness of different fire prevention measures, a set of previously validated [17] Boolean expressions was implemented. This covers nine different identified preventive measures presented in table 1. In the table, the level of correct classification from the validation study is also presented. This is based on a comparison for 144 cases where the fire investigation reports was first analysed and then the set of Boolean expressions introduced above was applied to the same cases and the level of agreement between the two methods was assessed. For further details on the validation procedure, see [5].

Table 1. Fraction of correctly classified cases when comparing fire investigation reports and the statistical classification methodology for a subset of 160 fire fatalities from 144 fatal fires. Adopted from [5]

Measure	Fraction of correct classification
Fully functioning electrical system	94 %
Flame resistant bedding	96 %
… sofas/armchairs	98%

… clothes	90%
Stove guard	98 %
Safe cigarettes	99 %
Thermally activated sprinkler system	88 %
Detector activated fire suppression (in bedroom and living room)	95 %
Smoke alarm (according to law)	91 %

The results showed a high level of agreement and therefore, the same set of expressions was used on the larger dataset with 1856 cases in the current paper.

In terms of "effectiveness", this is a measure based on the assumption that the intervention would have both perfect reliability and be effective (e.g. a sprinkler system would control a fire or a smoke alarm would wake the potential victim). In reality, of course, this is not always the case and should therefore be accounted for when, for example, performing a cost-benefit-analysis based on the data presented in this paper.

The main focus of the current paper was to compare cases where a specific intervention would have been effective and where it would not have been effective. This is performed through the calculation of an odds ratio per variable. The odds ratio is the ratio of the odds of an outcome (in this case an intervention being effective) in the presence of a specific factor (e.g. living in an apartment) and the odds in the absence of this factor. Therefore, an odds ratio above one indicates that the presence of that factor increases the likelihood of the intervention being effective compared to a situation with the absence of that factor. The odds ratio is complemented with confidence intervals.

Only factors which have a statistically significant influence on the outcome (i.e. the odds ratio is statistically significantly above one) are presented in this paper. The statistical significance of the difference is calculated using a t-test for two independent samples. Since the sampling distribution is positively skewed, a logarithmic scale transformation is performed to compute the standard normal deviate (i.e. z-score) [22].

Due to the large number of hypothesis tests (in total 40 tests/variables) the significance level needs to be corrected to reduce the risk of type-I error. Since the most common procedure to perform this correction, Bonferroni correction, tend to inflate the number of type II-errors when the number of tests are large, a different, also well established, statistical method was employed called the Benjamini-Hochberg procedure [23]. The rationale behind this method is that it is the fraction of the rejected hypothesis that are false that are of interested, in contrast to the p-value of each specific test. In this method, a False Discovery Rate (FDR) is used instead of a corrected p-value and values of FDR between

10 % and 20 % has been suggested [24]. In this study, an FDR of 10 % is used to restrict the type-I error which are judged to more detrimental to the analysis compared to type-II errors.

To be able to calculate odds ratios for smoking, a probability of an individual being a smoker was predicted using the fraction of smokers in the population in 10-years-groups by gender obtained from a national survey of smoking habits performed in 2008 [25]. The reason for choosing this year was that there has been a significant reduction in number of smokers over the years and therefore a year in the middle of the studied period was chosen. Victims who died in a fire caused by their own smoking was given a 100% probability of being a smoker. Through this, the expected number of smokers could be calculated for both cases and controls.

Results

In this section, the sociodemographic factors that indicate that a specific intervention is more or less effective are presented. However, it should be noted that although an intervention can break a causal chain in a specific scenario, no strict causality is inferred between the studied sociodemographic variables (e.g. age, living conditions) and the effectiveness. Importantly, however, this is not needed since the importance of the present study in relation to prevention is to map the sociodemographic cues that point towards a measure being more or less effective for a specific individual.

The results are presented as odds ratio (OR) with 95% confidence intervals and only statistically significant variables are presented. For a full list of included variables, refer to appendix A. To improve graphical interpretation, when a sociodemographic factor was present for all (or none) of the cases, this is presented as a cross at odds ratio of 100 and 0.01, respectively, despite actually being at infinity and minus infinity.

The results for safe cigarettes can be found in figure 1. Apart from the obvious importance of the individual being a smoker, the living conditions appear to be very important where living in a care home (OR=3.6; 95% CI, 2.2 – 5.8) is most important followed by living alone (OR=2.9; 95% CI, 2.2 – 3.8) and in an apartment (OR=2.2; 95% CI, 1.7 – 2.7). Also, factors relating to age are important, specifically being between 65 and 79 years (OR=2.1; 95% CI, 1.6 – 2.7) as well as alcohol intake (with an OR of 2.0 (95 % CI, 1.5-2.7) for BAC above 2‰). Also, several factors relating to larger cities such as a population above 100k (OR=1.7; 95% CI, 1.4 – 2.2) appear to be indicators of high effectiveness of the intervention.

Many of the factors that indicate a lower effectiveness are the opposite of the factors described above. For example, younger ages, with 20-44 years at OR of 0.3 (95% CI, 0.2 – 0.4) and no individuals where the measure would have been effective for victims below 20 years. Also, living with family (OR=0.3; 95% CI, 0.2 – 0.4) and living in a house (OR=0.3; 95% CI, 0.2 – 0.4) as well as living in smaller cities are indicators of the measure being less effective.

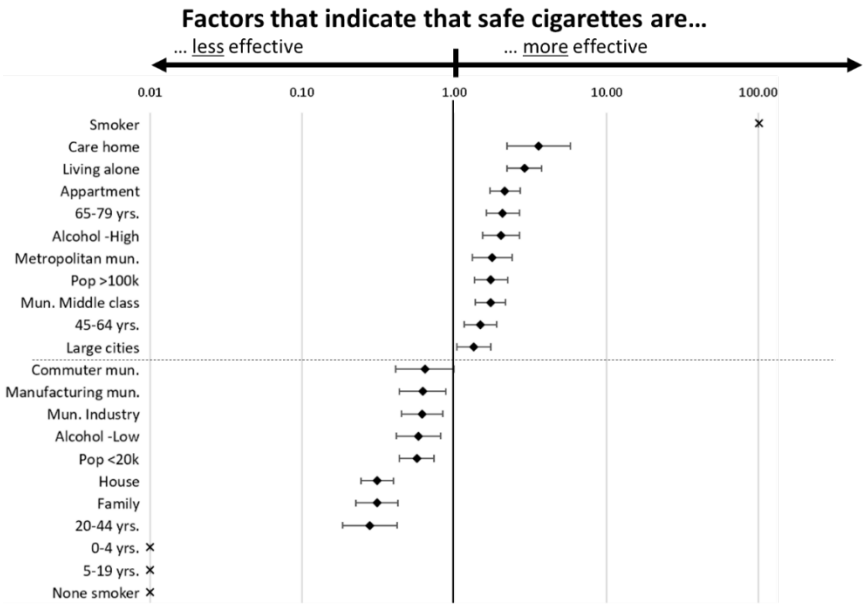

Figure 1. Odds-ratios of different sociodemographic factors on the effectiveness of safe cigarettes.

Factors relating to the effectiveness of a functional electrical system can be found in figure 2. In this context, a functional electrical system refers to both fixed installations and electrical consumer products. The strongest indicator of effectiveness is the absence of smoking (OR=7,3; 95% CI, 4.2 – 12.6) which indicates that those individuals would benefit more from measures targeting smoking related fires. Also, younger people, specifically 5-19 years (OR=5.5; 95% CI, 2.8 – 10.9) living in houses (OR=2.6; 95% CI, 1.8 – 3.8) with their family (OR=2.1; 95% CI, 1.4 – 3.1) seems to benefit more from this intervention. Also, people in high income municipalities (OR=2.4; 95% CI, 1.4 – 4.1) and people not being under the influence of alcohol (OR=1.5; 95% CI, 1.1 – 2.2) tend to benefit more from this measure.

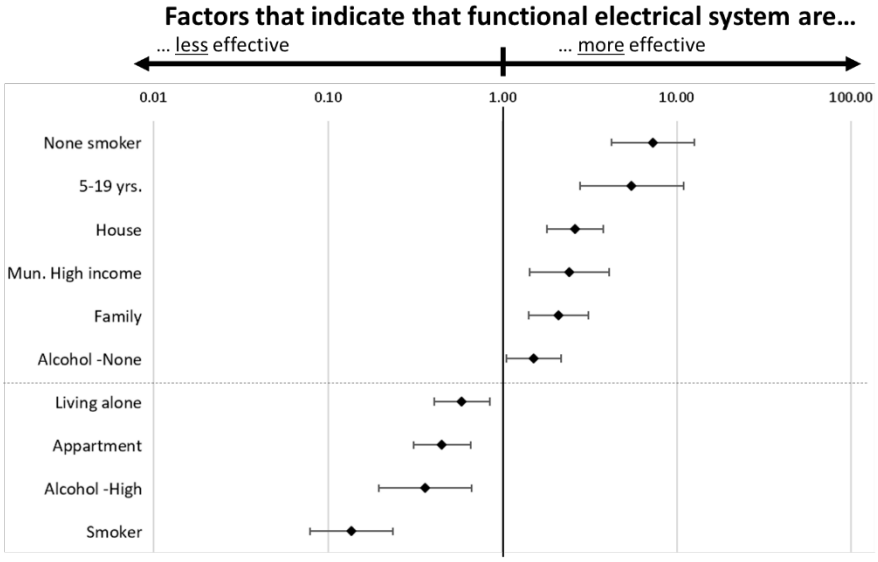

Figure 2. Odds-ratios of different sociodemographic factors on the effectiveness of functional electrical system.

Factors influencing the effectiveness of fire resistance of sofas and armchairs can be found in figure 3. Among the factors indicating a high level of effectiveness, the presence of smoking can be found (OR=4.2; 95% CI, 2.9 – 6.1) as well as living in an apartment (OR=3.4; 95% CI, 2.3 – 5.0), a BAC above 2‰ (OR=2.7; 95% CI, 1.9 – 3.9), living alone (OR=2.2; 95% CI, 1.5 – 3.3), and being between 45 and 64 years of age (OR=1.6; 95% CI, 1.1 – 2.2).

The factors indicating low effectiveness are to a large degree the opposite of the factors above, but it is interesting to note that the oldest age group, 80+, indicated a low effectiveness (OR=0.4; 95% CI, 0.2 – 0.6) as for those living in care home (OR=0.3; 95% CI, 0.1 – 0.8).

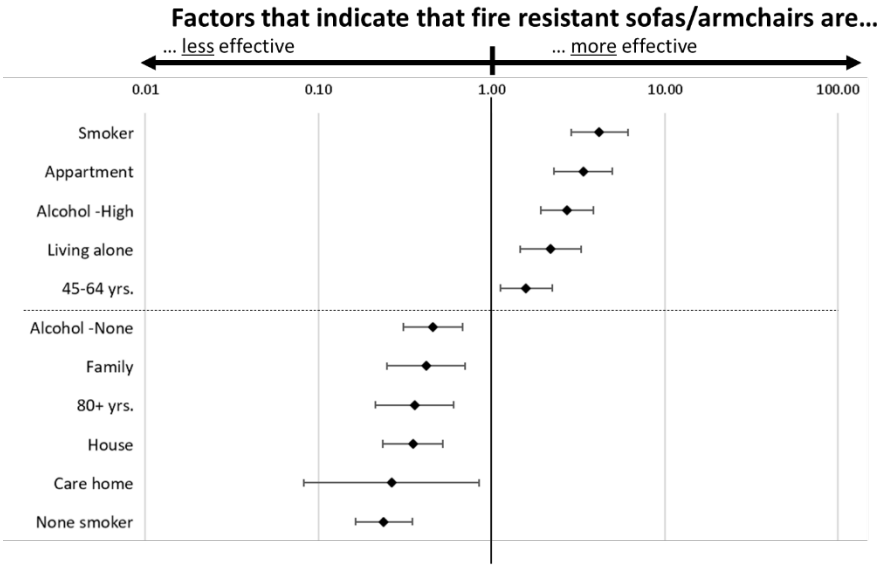

Figure 3. Odds-ratios of different sociodemographic factors on the effectiveness of fire resistant sofas or armchairs.

The factors influencing the effectiveness of fire-resistant bedding is presented in figure 4. Those factors are to a large degree similar to the factors found for fire-resistant sofas and armchairs but factors relating to the type of municipality also showed a significant predictive capability. It was found that individuals living in metropolitan (OR=1.7; 95% CI, 1.2 – 2.4) and middle class (OR=1.5; 95% CI, 1.1 – 2.0) municipalities could be expected to benefit more from fire-resistant bedding.

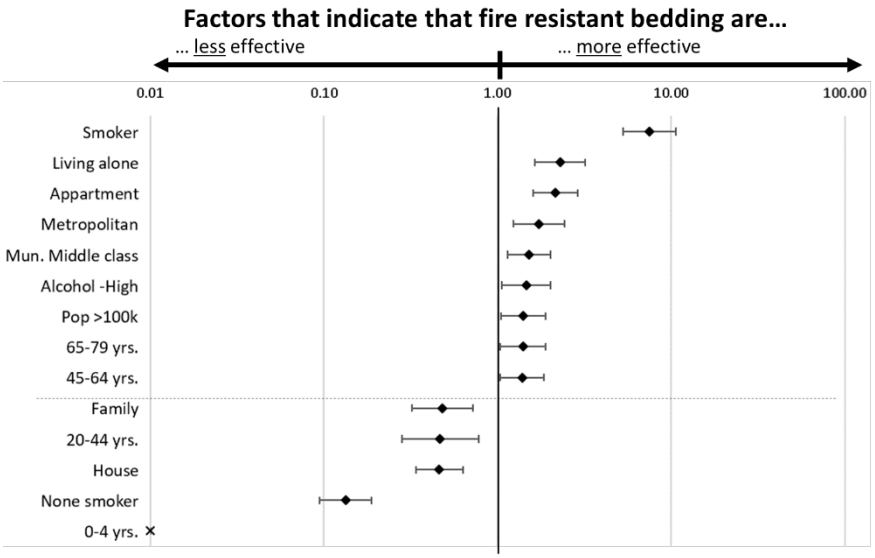

Figure 4. Odds-ratios of different sociodemographic factors on the effectiveness of fire resistant bedding.

Factors that indicate a high effectiveness of fire-resistant clothes can be found in figure 5 and differs to a large degree from the ones presented above. In this case, the oldest group, 80+ years (OR=4.9; 95% CI, 3.4 – 7.1) and those living in care homes (OR=11.9; 95% CI, 7.4 – 19.1) benefit most. Interestingly, people with moderate (OR=0.4; 95% CI, 0.2 – 0.7) or high (OR=0.1; 95% CI, 0.0 – 0.3) alcohol levels benefit less. There also seems to be a gender difference with women benefiting more (OR=2.6; 95% CI, 1.8 – 3.8) and men benefiting less (OR=0.4; 95% CI, 0.3 – 0.5).

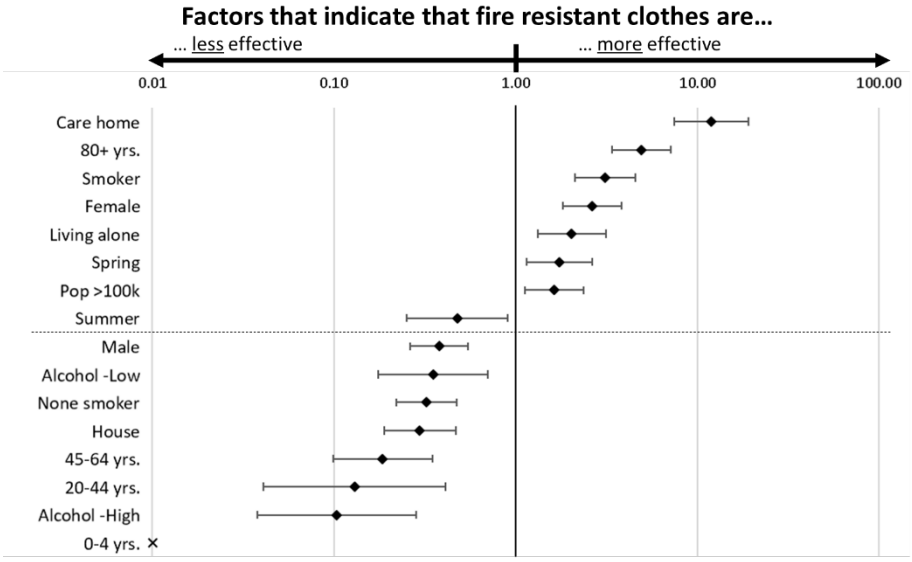

Figure 5. Odds-ratios of different sociodemographic factors on the effectiveness of fire resistant clothes.

Factors that indicate the level of effectiveness of smoke alarms can be found in figure 6. Among the factors that increase the effective of smoke alarms, both high (OR=2.8; 95% CI, 2.0 – 4.0) and low alcohol levels (OR=1.8; 95% CI, 1.2 – 2.6) can be found. A higher effectiveness can also be expected in more

sparsely populated municipalities (OR=2.4; 95% CI, 1.1 – 5.2) and municipalities with a low average income (OR=1.9; 95% CI, 1.2 – 2.8) as well as for people living in houses (OR=2.0; 95% CI, 1.5 – 2.6).

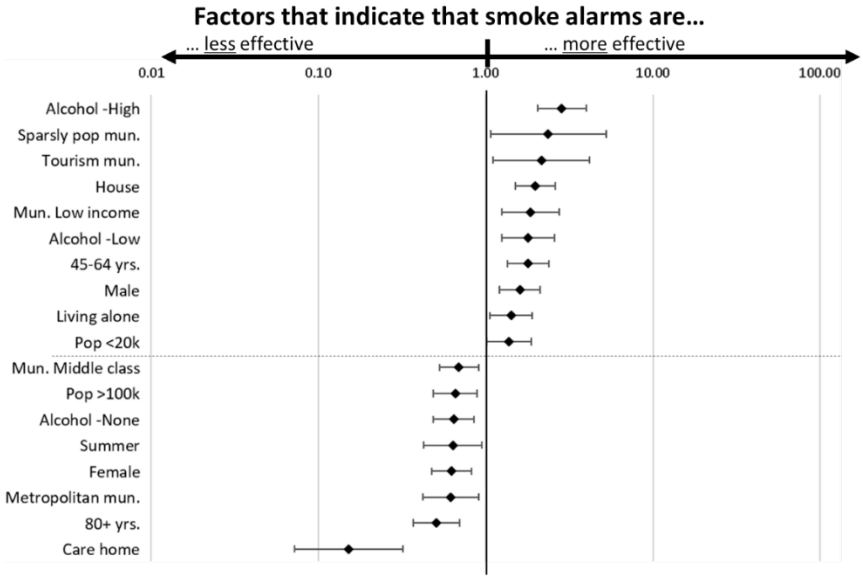

Figure 6. Odds-ratios of different sociodemographic factors on the effectiveness of smoke alarms.

For thermally activated sprinkler systems, factors indicating the level of effectiveness can be found in figure 7. The most important factor is the absence of smoking (OR=7.8; 95% CI, 5.6 – 10.8) which is likely to be due to the fact that fires affecting smokers tend to ignite in direct proximity to the victim where thermally activated sprinkler systems has been shown to be too slow to prevent the fatality [26]. Thermally activated sprinkler systems are more effective for younger people, specifically 20-44 years (OR=1.8; 95% CI, 1.1 – 2.9), living in houses (OR=2.2; 95% CI, 1.6 – 2.9) and less effective for people in care homes (OR=0.3; 95% CI, 0.2 – 0.5).

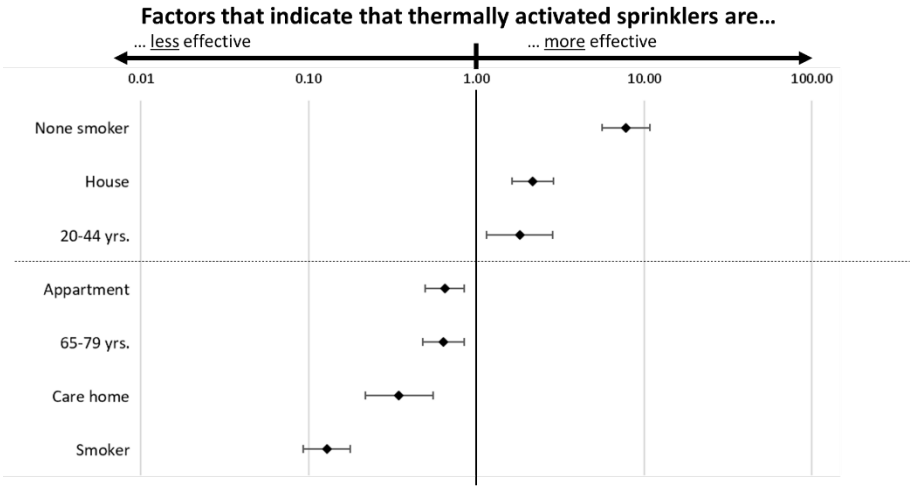

Figure 7. Odds-ratios of different sociodemographic factors on the effectiveness of thermally activated sprinkler systems.

As an alternative to the thermally activated sprinkler systems, there are sprinkler systems available that activate on a detector (usually based on a combination of smoke and rate of temperature rise) which make the system significantly quicker. Due to the more complex technology, they are typically only installed in specific rooms such as bedroom and living room. Factors that indicate that this type of system is more or less effective is presented in figure 8.

As for several other measures, the presence of smoking is a strong indicator of the effectiveness (OR=3.5; 95% CI, 2.8 – 4.3) as well as living alone (OR=1.6; 95% CI, 1.3 – 1.9) and in an apartment (OR=2.2; 95% CI, 1.8 – 2.6). For this measure, also metropolitan (OR=1.6; 95% CI, 1.2 – 2.2) and middle class (OR=1.5; 95% CI, 1.2 – 1.8) municipalities indicate an increased effectiveness.

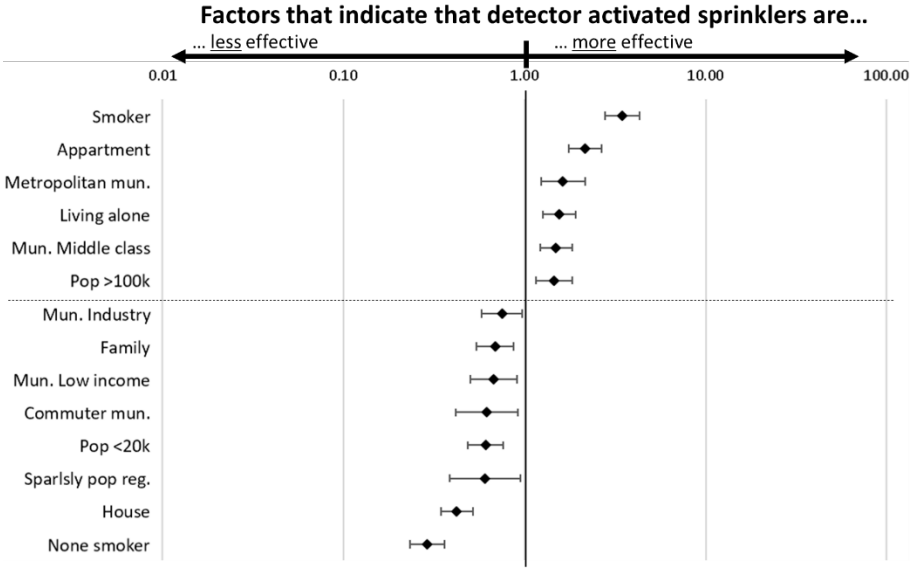

Figure 8. Odds-ratios of different sociodemographic factors on the effectiveness of detector activated sprinkler systems.

The results for the final intervention assessed in this study, stove guards, is presented in figure 9. For this intervention, commuter municipalities (OR=2.6; 95% CI, 1.5 –4.7) showed the greatest influence followed by both low (OR=1.9; 95% CI, 1.2 – 3.1) and high (OR=1.9; 95% CI, 1.2 – 2.9) alcohol levels. Also, younger adults, 20-44 years (OR=1.9; 95% CI, 1.2 – 3.1), appear to benefit more from stove guards.

Among the factors that indicate a lower effectiveness, are the absence of alcohol (OR=0.6; 95% CI, 0.4 – 0.9) and being in the oldest age group, 80+ years (OR=0.5; 95% CI, 0.3 – 0.8).

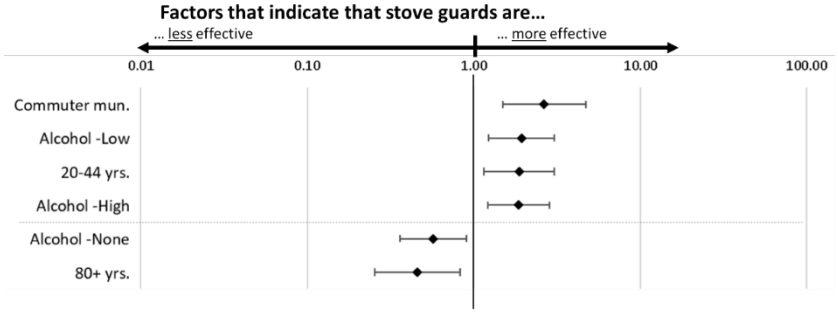

Figure 9. Odds-ratios of different sociodemographic factors on the effectiveness of stove guards.

Discussion

The results from this study clearly show the importance of matching the correct intervention to sociodemographic factors. This is perhaps most clearly illustrated by comparing the implementation of

safe cigarettes and a functional electrical system. When recommending interventions to a household it is obvious that in one household safe cigarettes could be exceedingly beneficial whilst in the non-smoking household this would have no effect. However, it is likely that in the non-smoking household a functional electrical system would be highly beneficial to limit the likelihood of a fatal fire.

Similarly, sprinklers and detector-activated sprinklers are beneficial for different societal groups. Specifically, sprinklers are more beneficial for younger non-smokers living in houses whilst detector-activated sprinklers are more beneficial for smokers living alone in apartments. This is an important differentiation and can have considerable effects on the recommendations surrounding the planning of residential properties.

The age-related element of flame-retardant materials is also a particularly interesting finding in this study. Previous studies have noted that cigarette-related fatal fires are not one type of fire, rather that there are two distinctly different types. The first is a group largely consisting of middle-aged men who are intoxicated and where the fire starts in the living room or on a sofa or bed. The second is a group largely consisting of older women, often in care homes, where the cigarette ignites their clothes [27]. These typologies are clearly visible in this study as well.

Another interesting finding is related to stove guards. Sweden has been highly proactive in free-of-charge installing stove guards in the homes of elderly, in particular for those with cognitive disabilities [28]. As such, the results concerning stove guards need to be elaborated on. Installing fire safety equipment in relation to cooking stoves is important and in particular for older individuals. In the US, people 85 years and older have a 5.5 times greater risk of dying in a cooking fire compared to the overall population [29]. As such, the Swedish programme of installing such equipment free-of-charge is important. However, this also means that a large proportion of older individuals in Sweden have such safety equipment and consequentially, the proportion of all fatal fires that are cooking-related is considerably less than in other countries. In the US, 21% of all residential fatal fires are caused by cooking-related activities [29] and in London, UK, 14% are caused by cooking [30]. In Sweden, the figure is 6% [27]. Consequentially, the potential effectiveness of interventions such as stove guards will be severely limited for the older population in Sweden and therefore the results suggest a greater effect for younger populations. Whilst this is likely to be true for Sweden, the transferability to other countries is dubious.

The example with stove guards highlights some limitations of this study. Firstly, by using the methodology chosen for this study, the theoretical effectiveness of an intervention will be related to the current safety situation in the studied population. As such, a widely implemented intervention will only have a potential effectiveness in groups that have yet to accept or chose the intervention, but will benefit from it. Although this is important knowledge, not least from a practitioner's perspective, as it will therefore be known where to focus campaigns and information, the knowledge is contextual. As such, similar studies need to be performed in other contexts.

The stove guard example also highlights that whilst it would be beneficial to install such equipment in younger adult homes, no cost-benefit or return of investment is possible to ascertain from the results. Most likely, given the relatively few fatal fires caused by stoves in Sweden, large resources would be required in order to accomplish significant results. However, Sweden has a Vision Zero policy in regards to residential fires meaning that a deontological, rather than utilitarian, perspective should be applied [31]. As such, in accordance with the approach, if benefits can be achieved, they should be pursued.

The results for smoke alarms also highlight another limitation of the study since they indicate that high alcohol levels indicate a high level of effectiveness. It should, however, be noted that the concept of theoretical effectiveness is based on the assumption that the preventive measure fills its purpose in the fire, which, in the case of a smoke alarm, is to wake the individual. However, experiments on intoxicated individual indicate that waking those individuals is significantly more difficult compared to non-intoxicated individuals [32] which is a factor one needs to account for when designing interventions.

As such, although the results in this study are somewhat contextual and therefore need to be assessed as such, they clearly illustrate an important factor; that one solution does not work for all. Rather, fire prevention interventions need to be specifically chosen for each individual depending upon the potential benefit and impact of an intervention. Currently, a “one size fits all” approach is commonly seen in fire prevention. This study shows that this needs to change in order for fire prevention interventions to become as effective as possible.

Conclusion

This study can show that in terms of different fire safety interventions, the effectiveness differs considerably depending upon sociodemographic factors. From a prevention, societal perspective it is exceedingly important to introduce the most effective intervention to the societal sub-group most in need. Hopefully, the results from this study can contribute to a more evidence-based, and effective, fire prevention strategies in the future.

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Appendix A. Detailed results

Table A.1 List of variables included in the analysis, with data source and odds ratio for the different preventive measures with 95 % confidence intervals. Statistically significant results (FDR<10 %) is marked in bold. "None"/"All" indicate that the measure was effective for none or all cases in that category.

Variable	Category	N	Odds ratio for … Electrical system	Safe cigarettes	FR Sofa/ armchair	FR Bedding	FR Clothes	Smoke alarm	Thermal sprinkler	Detector sprinkler	Stove guard
Age	1. 0-4	21	2.1 (0.59-7.48)	*None*	0.97 (0.22-4.28)	*None*	*None*	0.68 (0.17-2.72)	1.87 (0.43-8.14)	1.03 (0.42-2.54)	0.75 (0.1-5.71)
	2. 5-19	49	**5.53** (2.8-10.94)	*None*	0.39 (0.09-1.64)	0.24 (0.06-0.99)	0.99 (0.35-2.82)	1.13 (0.48-2.65)	9.23 (1.26-67.41)	0.99 (0.54-1.83)	0.63 (0.15-2.62)
	3. 20-44	240	0.88 (0.51-1.52)	**0.28** (0.18-0.42)	0.92 (0.56-1.52)	**0.47** (0.28-0.78)	**0.13** (0.04-0.41)	1.07 (0.73-1.56)	**1.81** (1.15-2.85)	0.84 (0.62-1.12)	**1.88** (1.15-3.06)
	4. 45-64	573	0.68 (0.44-1.04)	**1.48** (1.16-1.9)	**1.58** (1.12-2.23)	**1.39** (1.04-1.86)	**0.19** (0.1-0.35)	**1.79** (1.34-2.4)	0.78 (0.59-1.03)	0.93 (0.75-1.15)	1.2 (0.79-1.82)
	5. 65-79	534	0.69 (0.44-1.06)	**2.09** (1.62-2.69)	1.39 (0.98-1.99)	**1.4** (1.04-1.89)	1.14 (0.78-1.69)	0.97 (0.71-1.32)	**0.64** (0.48-0.84)	1 (0.8-1.25)	0.98 (0.63-1.53)
	6. 80+	439	1.37 (0.92-2.04)	0.83 (0.63-1.08)	**0.36** (0.21-0.6)	0.85 (0.61-1.2)	**4.92** (3.4-7.11)	**0.51** (0.37-0.7)	1.4 (1-1.96)	1.23 (0.97-1.57)	**0.46** (0.25-0.83)
Gender	Female	723	1.27 (0.88-1.83)	1.14 (0.9-1.43)	0.75 (0.53-1.06)	0.93 (0.7-1.24)	**2.64** (1.83-3.81)	**0.62** (0.47-0.82)	0.88 (0.67-1.15)	1.16 (0.94-1.42)	1.04 (0.7-1.56)
	Male	1133	0.79 (0.55-1.13)	0.88 (0.7-1.11)	1.34 (0.94-1.9)	1.07 (0.81-1.43)	**0.38** (0.26-0.55)	**1.6** (1.21-2.11)	1.14 (0.87-1.49)	0.86 (0.7-1.06)	0.96 (0.64-1.43)
Alcohol	High (>2‰)	389	**0.36** (0.2-0.67)	**2.03** (1.54-2.69)	**2.73** (1.91-3.88)	**1.46** (1.06-2.02)	**0.1** (0.04-0.28)	**2.85** (2.04-3.98)	0.74 (0.55-1.01)	1.08 (0.85-1.38)	**1.86** (1.21-2.85)
	Low (0.1-2‰)	309	1.45 (0.92-2.28)	**0.58** (0.42-0.81)	1.11 (0.71-1.73)	0.78 (0.52-1.17)	**0.35** (0.18-0.7)	**1.8** (1.25-2.58)	1.43 (0.96-2.12)	0.92 (0.7-1.21)	**1.94** (1.23-3.06)
	None (<0.1‰)	622	**1.52** (1.05-2.18)	0.82 (0.65-1.05)	**0.46** (0.31-0.68)	1.03 (0.77-1.38)	0.93 (0.64-1.34)	**0.64** (0.49-0.85)	0.93 (0.7-1.22)	0.98 (0.79-1.21)	**0.57** (0.36-0.9)
Municipality (class 1)	1 Municipalities with high income, high education	141	**2.41** (1.43-4.09)	0.65 (0.41-1.03)	0.62 (0.3-1.31)	0.59 (0.32-1.1)	0.82 (0.41-1.67)	1.02 (0.61-1.71)	1.47 (0.82-2.62)	1.06 (0.72-1.55)	0.73 (0.31-1.7)

	2 Traditional middle class municipalities	800	0.79 (0.55-1.13)	**1.73** (1.38-2.18)	1.14 (0.82-1.59)	**1.52** (1.15-2.01)	1.25 (0.87-1.78)	**0.69** (0.53-0.9)	0.79 (0.6-1.03)	**1.49** (1.22-1.83)	0.96 (0.64-1.42)
	3 Municipalities with tourism-related economy	321	0.73 (0.43-1.27)	0.82 (0.6-1.12)	1.13 (0.73-1.76)	0.87 (0.58-1.29)	0.75 (0.44-1.28)	1.21 (0.83-1.77)	0.84 (0.59-1.19)	0.89 (0.67-1.17)	1.35 (0.82-2.23)
	4 Municipalities with traditional industries	340	1.27 (0.8-2)	**0.62** (0.45-0.84)	0.69 (0.42-1.12)	0.65 (0.43-0.99)	1.14 (0.72-1.81)	0.97 (0.69-1.38)	1.27 (0.88-1.84)	**0.75** (0.58-0.98)	1.06 (0.63-1.77)
	5 Small municipalities with low income, low education and negative population growth	254	0.79 (0.42-1.46)	0.88 (0.61-1.25)	1.27 (0.78-2.07)	1 (0.65-1.55)	0.75 (0.4-1.4)	**1.85** (1.24-2.76)	1.3 (0.85-1.99)	**0.67** (0.5-0.91)	0.81 (0.42-1.54)
Municipality	1 Metropolitan municipalities	278	1.08 (0.68-1.72)	**1.78** (1.32-2.41)	0.79 (0.49-1.27)	**1.74** (1.24-2.44)	1.27 (0.82-1.98)	**0.62** (0.42-0.91)	0.68 (0.49-0.94)	**1.63** (1.23-2.17)	0.84 (0.48-1.48)
(class 2)	2 Suburban municipalities	225	1.43 (0.88-2.33)	0.92 (0.65-1.31)	0.92 (0.56-1.53)	1.05 (0.7-1.59)	0.57 (0.3-1.08)	0.76 (0.5-1.16)	0.92 (0.62-1.37)	1.13 (0.83-1.53)	0.71 (0.36-1.38)
	3 Large cities	440	0.81 (0.52-1.26)	**1.35** (1.04-1.75)	1.43 (0.99-2.06)	0.88 (0.63-1.23)	1.31 (0.88-1.94)	1.01 (0.74-1.36)	1.09 (0.8-1.5)	1.2 (0.94-1.52)	0.92 (0.57-1.47)
	4 Suburban municipalities to large cities	67	1.13 (0.44-2.92)	0.56 (0.29-1.09)	0.88 (0.34-2.26)	0.93 (0.43-2.01)	1.08 (0.42-2.79)	1.29 (0.64-2.59)	1.02 (0.49-2.12)	0.86 (0.5-1.48)	1.44 (0.56-3.7)
	5 Commuter municipalities	147	1.15 (0.58-2.28)	**0.64** (0.41-1.00)	0.41 (0.17-1.04)	0.96 (0.55-1.68)	0.5 (0.2-1.24)	1.16 (0.69-1.96)	1.34 (0.76-2.35)	**0.62** (0.42-0.91)	**2.65** (1.49-4.7)
	6 Tourism and travel industry municipalities	94	0.64 (0.23-1.81)	1.03 (0.6-1.76)	1.32 (0.64-2.73)	0.68 (0.32-1.45)	0.79 (0.31-2.02)	**2.15** (1.11-4.18)	0.82 (0.46-1.47)	0.89 (0.56-1.42)	1.03 (0.41-2.62)

Table A.1 (cont.) List of variables included in the analysis, with data source and odds ratio for the different preventive measures with 95 % confidence intervals. Statistically significant results (FDR<10 %) is marked in bold.

Variable	Category	N	Odds ratio for … Electrical system	Safe cigarettes	FR Sofa/ armchair	FR Bedding	FR Clothes	Smoke alarm	Thermal sprinkler	Detector sprinkler	Stove guard
Municipality (class 2)	7 Manufacturing municipalities	249	1.08 (0.64-1.82)	**0.62** (0.44-0.88)	0.92 (0.55-1.52)	0.71 (0.45-1.12)	1.26 (0.77-2.07)	0.97 (0.66-1.43)	1.26 (0.82-1.95)	0.86 (0.63-1.17)	0.68 (0.35-1.33)
(*cont.*)	8 Sparsely populated municipalities	73	1.42 (0.54-3.72)	0.57 (0.28-1.16)	0.77 (0.27-2.19)	0.34 (0.1-1.11)	0.23 (0.03-1.72)	**2.37** (1.07-5.23)	1.32 (0.62-2.83)	0.65 (0.39-1.11)	1.35 (0.53-3.47)
	9 Municipalities in densely populated regions	192	0.82 (0.43-1.57)	0.92 (0.63-1.36)	1.13 (0.66-1.93)	1.02 (0.64-1.63)	1.06 (0.59-1.9)	0.89 (0.56-1.4)	0.88 (0.58-1.34)	0.88 (0.63-1.21)	0.93 (0.47-1.82)
	10 Municipalities in sparsely populated regions	91	0.53 (0.16-1.72)	0.86 (0.48-1.55)	1.19 (0.55-2.55)	1.18 (0.62-2.25)	0.9 (0.35-2.29)	1.8 (0.94-3.45)	1.71 (0.85-3.48)	**0.61** (0.39-0.95)	1.02 (0.4-2.58)
Population	1 0-19999 inhabitants	549	1.06 (0.7-1.6)	**0.57** (0.43-0.74)	0.84 (0.56-1.24)	0.78 (0.56-1.09)	0.8 (0.52-1.23)	**1.38** (1.02-1.86)	1.23 (0.9-1.68)	**0.61** (0.49-0.76)	1.44 (0.95-2.2)
	2 20000-99999 inhabitants	827	1.19 (0.83-1.71)	0.98 (0.78-1.23)	1.11 (0.79-1.55)	0.89 (0.67-1.18)	0.76 (0.53-1.09)	1.09 (0.83-1.42)	1.12 (0.86-1.47)	1.1 (0.9-1.35)	0.89 (0.6-1.33)
	3 100000+ inhabitants	480	0.76 (0.5-1.15)	**1.74** (1.36-2.24)	1.04 (0.72-1.49)	**1.41** (1.05-1.89)	**1.63** (1.13-2.36)	**0.66** (0.49-0.89)	0.72 (0.54-0.96)	**1.46** (1.16-1.83)	0.78 (0.49-1.24)
Season	Winter	845	0.91 (0.63-1.31)	0.89 (0.71-1.13)	0.93 (0.67-1.3)	1.09 (0.82-1.44)	1.22 (0.85-1.74)	1.13 (0.87-1.48)	1.31 (1-1.72)	0.95 (0.78-1.16)	1.11 (0.75-1.66)
	Spring	311	1.04 (0.65-1.68)	1.19 (0.88-1.6)	1.28 (0.84-1.96)	0.65 (0.43-0.99)	**1.74** (1.14-2.64)	0.9 (0.63-1.28)	0.98 (0.69-1.4)	0.88 (0.67-1.14)	1.28 (0.78-2.08)

	Summer	262	1.26 (0.78-2.03)	0.98 (0.71-1.34)	0.87 (0.53-1.41)	1.09 (0.75-1.6)	**0.48** (0.25-0.9)	**0.64** (0.43-0.95)	0.68 (0.48-0.96)	1.11 (0.83-1.49)	0.73 (0.4-1.36)
	Autumn	438	0.93 (0.6-1.44)	1.03 (0.79-1.35)	0.99 (0.67-1.46)	1.12 (0.81-1.55)	0.68 (0.43-1.08)	1.22 (0.89-1.67)	0.94 (0.69-1.28)	1.11 (0.87-1.41)	0.85 (0.52-1.38)
Building type	Care	93	0.42 (0.15-1.15)	**3.58 (2.21-5.8)**	**0.26** (0.08-0.85)	0.83 (0.45-1.52)	**11.92** (7.44-19.09)	**0.15** (0.07-0.32)	**0.34** (0.22-0.55)	1.51 (0.95-2.39)	0.15 (0.02-1.09)
	Apartment	832	**0.45** (0.31-0.66)	**2.16 (1.71-2.72)**	**3.37** (2.29-4.96)	**2.16** (1.61-2.9)	0.86 (0.6-1.23)	0.77 (0.59-1.01)	**0.65** (0.5-0.85)	**2.16** (1.76-2.65)	1.3 (0.87-1.94)
	House	931	**2.61** (1.8-3.79)	**0.31** (0.24-0.4)	**0.35** (0.24-0.52)	**0.46** (0.34-0.63)	**0.3** (0.19-0.47)	1.98 (1.51-2.6)	**2.17** (1.63-2.89)	**0.42** (0.34-0.52)	0.94 (0.63-1.41)
Living	Living alone	1140	**0.58** (0.41-0.84)	**2.9 (2.23-3.77)**	**2.19** (1.46-3.29)	**2.29** (1.64-3.21)	**2.03** (1.32-3.14)	**1.42** (1.06-1.9)	0.77 (0.57-1.02)	**1.55** (1.26-1.92)	1.06 (0.7-1.62)
condition	Family	422	**2.1** (1.42-3.11)	**0.31** (0.23-0.43)	**0.42** (0.25-0.71)	**0.48** (0.32-0.72)	0.67 (0.41-1.09)	0.83 (0.6-1.15)	1.22 (0.88-1.7)	**0.69** (0.54-0.87)	0.91 (0.56-1.48)
Smoker	Yes	690	**0.14** (0.08-0.24)	*All*	**4.19** (2.88-6.1)	**7.5** (5.3-10.59)	**3.1** (2.11-4.56)	1.27 (0.97-1.67)	**0.13** (0.09-0.18)	**3.46** (2.77-4.32)	0.21 (0.12-0.37)
	No	1166	**7.31** (4.24-12.62)	*None*	**0.24** (0.16-0.35)	**0.13** (0.09-0.19)	**0.32** (0.22-0.47)	0.79 (0.6-1.03)	**7.79** (5.64-10.76)	**0.29** (0.23-0.36)	4.7 (2.7-8.18)

Bilaga 3. Förutsättningar för implementering (AP3)

Working paper

A Theoretical Examination of the Implementation of National Imperatives Concerning Individualized Fire Safety (IFS) for Elderly People

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Highlights:

- Study using semi-structured interviews with various authorities having jurisdiction
- Assessment efforts to personalize fire safety using a Consolidated Framework for Implementation Research
- Facilitators and barriers for implementation of IFS for broader national acceptance

Abstract

In 2010, the Swedish Civil Contingencies Agency (MSB) announced a "vision zero" of zero fire deaths in Sweden by 2050. Studies into fire deaths have identified that certain risk groups, including but not limited to elderly people, are overrepresented in fire death statistics in Sweden. The MSB has developed guidelines for how individualised fire safety (IFS) can be implemented in local communities for at risk groups, in support of their vision zero for fire deaths. This paper presents the results of an interview study with a selection of Swedish municipalities to further explore how municipalities are working with IFS programs for community dwelling elderly people. The Consolidated Framework for Implementation Research (CFIR) has been used to analyse data developed through semi-structured interviews, from an analysis of the delegation of authority from MSB to local level and assessment of secondary documentation from national, regional and local organisations. The analysis has identified that IFS has, indeed, been implemented to varying degrees in Sweden, but that there are both facilitators and barriers which can be further leveraged to improve the implementation of IFS in the future.

Keywords: personalized fire safety, vision zero, CFIR, Consolidated Framework for Implementation Research, implementation research,

Introduction

Despite a significant decrease in the number of fire deaths in Sweden since the 1950's [1], the number of fire related fatalities has been relatively constant at approximately 100 per year. Of those who die in fires each year, approximately 75% die in their homes [2]. One group that appears to be particularly at risk is

elderly people [3, 4]. Given predictions of an aging society [5], it is reasonable to expect the number of fire fatalities to grow rather than decline in this group.

Risk factors that have been identified for elderly people include but are not limited to, a decreased ability to prevent a fire incident, reduced ability to respond to a fire incident and a reduced ability to remove themselves from the fire scene, circumstances which can all exacerbate the situation leading to a fatality [6]. Reduced function can be related to a variety of diseases, such as cardiovascular disease and impaired immune system [7, 8], but also functional limitations associated with aging, such as reduced physical strength and stamina, cognitive challenges, hearing difficulty and reduced sight [9]. Numerous technical systems designed to reduce the risk of fires are compromised due to the natural physical and psychological challenges associate with aging, e.g. there are indications that traditional domestic smoke alarms may have reduced efficacy in this group [10, 11]. Exacerbating this situation, Sweden has an age-in-place principle, which has resulted in a large proportion of frail elderly people living alone with support from home care rather than in nursing facilities [12].

As early as the 1990's, the Swedish parliament as one of the first countries in Europe, adopted a vision of zero deaths in road traffic [13-15]. Although the question of success or otherwise of such a vision is naturally subjective and complex, numerous studies have typically found the vision zero for road traffic deaths to be largely successful [16-19]. In Sweden, the "Vision Zero" terminology has consequently spread to other policy areas, ranging from suicide prevention to drug use in schools [20]. In 2010, the Swedish Civil Contingencies Agency (MSB) issued a Vision Zero concerning fire deaths for Sweden [21]. This adoption has resulted in numerous initiatives to understand the question of who dies in fires in Sweden, and how these might be prevented [1-4, 11, 22-25]. Identification of the fact that most fire fatalities occur in homes, and that elderly people represent a particularly vulnerable risk group, lead MSB to issue public guidelines to the Municipal Fire and Rescue Services (FRS) concerning individualised fire safety (IFS) in 2013 [26]. In this context, a number of risk groups were identified, based on whether they exhibited behaviour leading to an increased fire risk, had a limited ability to identify a fire, or had a limited ability to respond to a fire. Using these identification criteria, those in need of IFS were grouped depending on whether they are living in assisted accommodation, living in their homes (either with additional support or not) and whether they have addictions or mental health problems. Elderly persons, the focus of this article, are potentially represented in all four groups. The concept of IFS, is then based on an evaluation of the individual's needs and capabilities and identification of suitable measures to reduce the fire risk.

There are, however, significant challenges for the FRS to implement IFS in homes. In 2017, all Swedish municipalities were contacted to survey their ongoing or planned activities in relation to IFS for risk groups. In total 70% of municipalities provided answers, of which 52% reported that they were actively implementing the concept of IFS in homes for risk groups [27]. In many cases, however, free text answers indicated that the municipalities did not have a systematic approach, possibly due to the somewhat fragmented question of which local governmental agency is responsible for implementation of preventative or mitigation measures, i.e. health care, social services or the FRS. The health care and social services personnel in the municipalities regularly visit many frail elderly people in their homes but are lacking knowledge of fire safety. In the case of fire safety, the FRS possess the necessary expertise concerning early warning signs and technical systems to mitigate specific fire risks but does not have regular access to risk groups in their homes. Municipalities that indicated that they were not providing IFS in the home in the 2017 survey identified a number of reasons for this lack of service, e.g. lack of personnel and technical resources, unclear division of responsibilities between service providers, potentially conflicting priorities between difference providers and the challenge of collaboration across different organisations and budgets.

The question of IFS and its implementation is complex, requiring more in-depth results to analyse facilitators and potential barriers to the implementation of IFS in homes. This paper presents the results of an interview study with a selection of Swedish municipalities to further explore how municipalities are working with individualised home fire safety programs; and, if they report on-going activities in this field, to explore the extent of these activities. Ultimately, the aim of this work has been to explore barriers and facilitators for implementation of IFS interventions in Swedish municipalities as a basis for recommendations concerning said implementation. The Consolidated Framework for Implementation Research (CFIR) presented by Damschroder et al. [28], has been applied as a tool for the analysis.

Home care and safety for Elderly People in Sweden

In Sweden care of the elderly is usually provided in their home by health care and social services. The responsibilities of such care is far ranging, including aspects both of medical care (e.g. dispensing of medicines), occupational and physiotherapy, nutrition, and creating a safe environment. One aspect of safety for elderly people is fire safety, but other aspects include, but are not limited to, fall risks. Home care and safety of the elderly is governed at levels:

1. **National level.** At a national level the Health and Medical Services Act (SFS2017:30) defines that all citizens are entitled to good health and care, taking into account every individuals' equal value and dignity. Little information is given in this fundamental act as to how care shall be provided and who is responsible for this provision, although regional and local government and non-government actors are identified. Similarly, the provision of societal protection is defined in the Civil Protection Act (SFS2003:778). In the case of the Civil Protection Act, however, it is clearly stated that the municipality is responsible for the provision of a FRS. At this level, the instruments of the national government are legislation, policy declarations, various financial instruments and reporting requirements or supervision of healthcare outputs. The details of the provision of care is to be developed at the regional and/or local level. Finally, the Housing Adaptation Grant Act (SFS2018:222) governs which physical features can be adapted in homes to support people to live independently in their homes, and the Patients' Rights Act (SFS2014:821) strengthens the individual's personal integrity and right to decide their specific needs albeit based on expert input from care givers.
2. **Regional level.** The counties (often called regions) are responsible for the provision of health care in hospitals and primary outpatient care. Decisions concerning this responsibility are made by a designated County Administrative Board. The counties are not responsible for FRS as these are the responsibility of the municipality; but, in some cases collaboration between municipalities creates federations of municipalities creating something similar to counties for the FRS.
3. **Local level.** The municipalities are responsible for social services including residential care of the elderly. Social service is governed by the Social Services Act (SFS2001:453) but since the early 1992's a reform moved most home health care for elderly people to the local level including both home care and nursing homes. The municipalities are responsible for the provision of a functional local FRS.

The division of responsibilities described above is further complicated by the fact that for the sake of efficiency, the FRS has been organised into more or less strongly bound federations or collaborations, which do not necessarily match the region or county division. Figure 1 shows which municipal FRS are organised into federations, collaborations or remain entirely autonomous.

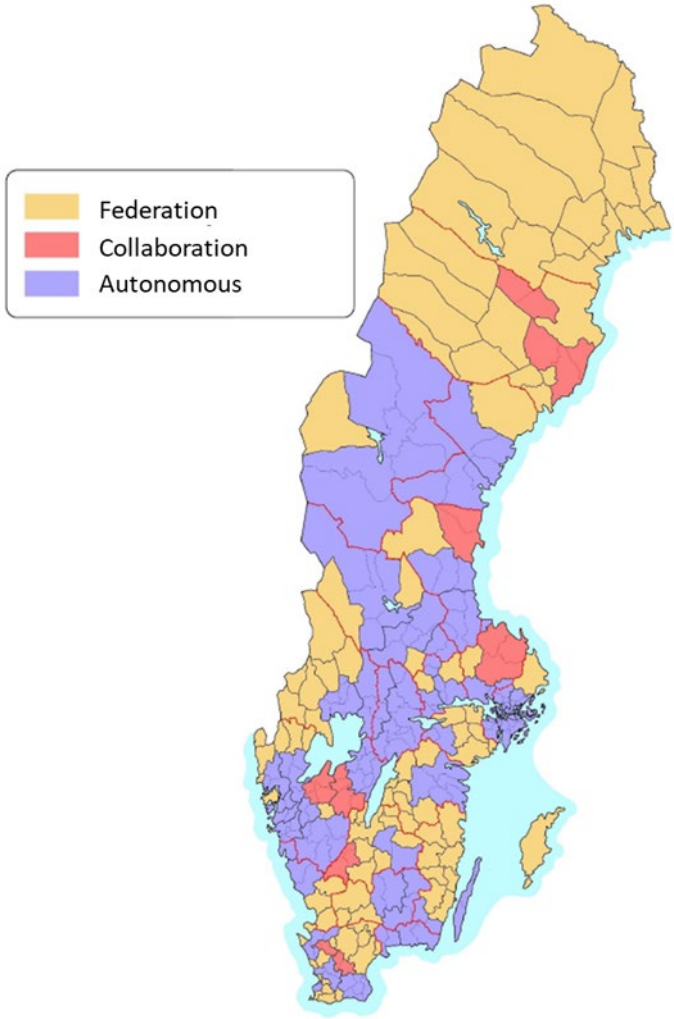

Figure 1: Map of Sweden showing the location of FRS federations, collaborations or autonomous municipal services. The red lines on the map show the boundaries between the various counties in Sweden and the grey lines show boundaries between the individual municipalities.

In total there are presently 21 counties in Sweden, although this number has varied over time. Each county has a board headed by a governor with the charge to supervise local government administration and to coordinate between the local and national government levels. The Government has delegated regulation of the FRS to the MSB at the national level, although the oversight role is further delegated to the County Administrative Board at the regional level. In the case of healthcare and social services the Government has delegated regulation to the National Board of Health and Welfare and the Swedish Agency for Health and Care Analysis at national level. The common interests of the municipalities and regions are in turn represented in many settings by a non-profit stakeholder organisation funded by the municipalities and regions on a proportional population basis called the Swedish Association of Local Authorities and Regions (SALAR). At the local level, the Local Government Act (SFS 2017:725) awards municipalities a high degree of autonomy expressed through their publically elected political boards. This inherent autonomy allows each municipality and region to decide on the local organisation of their services, such as fire services and healthcare. The municipalities staff the specific fire safety, healthcare and social

services for the citizens. Annual planning for the services is governed by municipal business planning while in the case of the FRS there is an additional layer of planning directly to MSB at the national level which is on a triannual basis rather than an annual basis.

Figure 2 gives an overview of this division of responsibilities and governance of fire safety, healthcare and social services for Swedish elderly citizens in their homes.

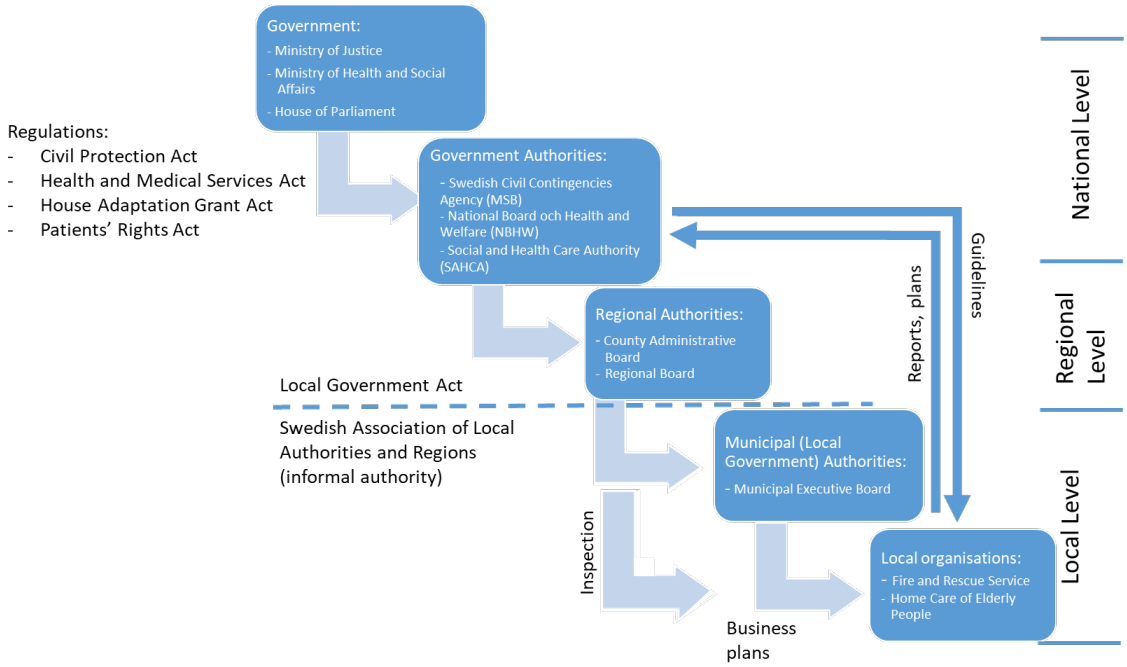

Figure 2: Overview of responsibilities and decision making for fire safety, healthcare and social services for Swedish elderly citizens.

Theoretical Framework

Implementation of interventions and research into practical context is not an easy undertaking. Indeed, there are indications that attempts to introduce change fail in at least two-thirds of cases [29]. A wide variety of constructs have been developed to analyse the interplay between an intervention and its implementation [30]. The theoretical framework presented by Damschroder et al. [28] has synthesised 19 underlying constructs in the Consolidated Framework for Implementation Research (CFIR) to identify key factors for implementation.

The CFIR identifies five separate dimensions, key to understanding an implementation:

1. **Intervention characteristics.** This described the characteristics of the intervention itself and how these support implementation, e.g. the source of the intervention, the body of evidence to support the intervention and its quality, the advantage of the intervention relative to existing methods, the adaptability of the intervention, its scalability and complexity, the design quality and packaging and finally the cost.

2. **Outer setting.** This describes the external context of the intervention, e.g. recipient needs and resources, the existence of supportive external networks, external peer pressure for change and external policies and incentives.
3. **Inner setting.** This describes the internal context of the intervention, e.g. the internal organisational structure, supportive internal networks and communication, the internal culture, the implementation climate and readiness for implementation.
4. **Characteristics of individuals.** This describes the ability of individual's charged with implementing the intervention, e.g. knowledge and beliefs about the intervention, self-efficacy, the individual's personal stage of change, loyalty of the individual towards the organisation and other personal attributes such as tolerance for change, values, capacity and competence.
5. **Process.** This describes the existence of a process for the intervention, e.g. the existence of a planned process, the process for recruitment of individuals and champions, the execution of the implementation and the existence of a process for reflection and evaluation of the implementation.

In this study, the CFIR has been used as the lens for the analysis to identify what in these five dimensions and the underlying attributes offer support or barriers to broad implementation of IFS. Since this framework was developed within the health care sector, the term patient is used in the original work by Damschroder et al. [28]; but, for the purpose of this study, the client concept has been used instead.

Method

For this study, a cross-sectional study-design was used and the purposeful sampling strategy was applied to obtain a maximum variation [31] in experiences of IFS. The primary and secondary data collected as part of this study was analysed using the lens of the CFIR [28]. The study was approved by the Swedish Ethical Review Authority (No. 2019-04163). This section presents the methodology in more detail as a backdrop for the later analysis of both primary and secondary data sources.

Sample

The primary data consisted of semi-structured interviews with twelve interview participants. The majority were from the FRS. The two non-FRS were one from the municipal (pop 10 000) home services and one elderly person who was interviewed in conjunction with the observation of a home visit specifically **after** a fire in her home. See Table 1 for summary of interviews.

The sampling procedure started with identifying persons in the FRS and was based on a combination of following criteria:

1. Indication of implementation of individualised fire protection for elderly people from the survey performed by Jönsson and Gustavsson [27]
2. Indication of unsuccessful implementation of individualised fire protection for elderly people from the survey performed by Jönsson and Gustavsson [27]
3. Availability to participate in the interviews in the time frame from January-May 2020
4. Geographical spread across the country
5. Governance, representing FRS federations and autonomous municipalities

During the sampling procedure, it became clear that home care in one of the municipalities identified was heavily involved in the development and implementation of IFS, and a representative for the social service in that municipality was interviewed. All of the identified persons were contacted, received information about the study and after informed consent, chose to participate in an interview. Some aspects of the study initially planned, e.g. multiple home visits, were interrupted due to the outbreak of the covid-19 pandemic, which is why only one such visit was conducted.

The secondary data used in this study included national laws, regulations and guidelines within the field, but also data that the participants provided in conjunction with their interviews such as local checklists, an information film and project reports. Table 1 includes a summary of the municipalities included in the study, the participant distribution (relating to the primary data associated with interviews) and secondary data.

Table 2: Summary of primary data in terms of number of interviewed participants, county/regional council and organization where the interview participants was employed and secondary data included. .

Organisational level	**Organisation**	**Primary data:** **Number of participants and type of data collection**	**Secondary data**
National	MSB – Swedish Civil Contingencies Agency		Various Guidelines Karlstads Agreement
National	Swedish Government		Laws and regulations
Municipality	Luleå autonomous FRS, Norrbotten	1 (virtual)	Checklist
County	Southern Federation (FRS), Federation Skåne North West	2* (home visit + virtual, the FRS representative in this interview was interviewed on two separate occasions) 1 (virtual)	Checklist YouTube video Project report including checklist
Municipality	Home care (social services) in Örkelljunga, Skåne	1 (virtual)	Project report including checklist
County	Federation Södertörn Fire Defence Association (FRS), Stockholm		Checklist

County	Attunda Federation, Uppland	6 (full day visit)	Guidelines
County	Federation Greater Gothenburg Area (FRS), Västra Götaland	1 (virtual)	Guidelines Checklist (Josefin data)

* One interview was conducted as part of an observation of a home visit with an elderly person living within the area of the Southern Federation (FRS) responsibility. The FRS representative was also interviewed virtually on a separate occasion.

Data collection

The starting point for the interview guide developed was the national guidelines about IFS [26]. Themes that were addressed during the interviews were: In what way does your organization specifically work on IFS? If your organisation does not work on IFS - why not and have you previously done so? Is your organisation planning to work on IFS –what are your plans and how long have you been planning for this? Which facilitators and barriers do you and your organisation experience in working with IFS?

The interviews were, due to practical reasons, done on site as well as via link or telephone. In one organisation, six participants were interviewed across a working day on site at the FRS with one author (JG). These interviews were divided into three sessions, one was conducted with three managers together, one with two operative personnel and one with a coordinator. The final interview focused specifically on guidelines for home visits. Five of the interviews were digital, conducted via zoom by two of the authors together (GC and MM), with one participant at a time. These interviews lasted for approximately 45 minutes each. One researcher led the interview and the other one took detailed notes and asked supplementary questions during the interviews. The final interview was conducted in conjunction with a home visit with an elderly person.

Data Analysis

For the analysis, a deductive approach was applied [32] to describe the interventions and identify barriers and facilitators to successful intervention against the backdrop of CFIR [28]. The five dimensions of CFIR and the underlying attributes of this theoretical framework guided the analysis. The reliability of the written notes were checked against the audio recorded interviews, in order to ensure that important data was not overlooked. The summaries of the interviews were entered into NVivo 12 and text was coded according to the dimensions and the underlying attributes in the CFIR [28]. During this coding process, the authors were open to introduce additional dimensions or attributes, but this was not necessary given that the framework is very accommodating.

To gain a deeper understanding of how the interventions were interpreted and implemented in the organisations, secondary data, e.g. the legal framework for the intervention, guidelines and checklists from MSB and municipalities were included (see Table 1). The material provided by the interviewed organisations was integrated into the results where relevant.

Both primary and secondary data were available to all authors and the analyses was made jointly with regular data analysis meetings. The interdisciplinary research team, consisting of a nurse, a fire safety professionals and an occupational therapist, facilitated the development of different perspectives during the analysis. The results were continually discussed between the authors until agreement was reached.

Illuminating quotes are presented to clarify how the empirical data supports the results. Note that all quotes have been translated from Swedish by the authors.

Results

The results of the analysis of the primary and secondary data is presented below, using the five dimensions of the theoretical framework CFIR and their underlying attributes.

Intervention Characteristics

Intervention source

To varying degrees, all participants referred to the MSB guidelines as the source of the initiative to develop IFS. The rationale for IFS was recognised in many cases as stemming from the concept of a vision zero for fire deaths. In some cases, the municipality had developed and applied IFS interventions for elderly people based on the intention described in the MSB guidelines, in others there had been efforts to implement the recommendations without a specific focus on IFS but rather on mitigation of fire risks for risk groups in general. There was clear respect for the source of the intervention (i.e. MSB) although the participants reported some frustration concerning the vagueness of the central guidance documents.

Evidence Strength & Quality

The participants expressed an understanding that the majority of fire deaths occur in homes and that certain risk groups are over-represented in the fire death statistics, e.g. elderly persons. The concept of vision zero was seen to be laudable but the connection between the vision and IFS interventions were seen to be tenuous, requiring local efforts for its implementation, i.e. an understanding of local conditions and networks guided the development of the intervention. There was local resistance to the implementation of IFS in certain communities, which might indicate that evidence strength and quality is perceived as lacking. In one interview, it was acknowledged that successful implementation in one community helped to strengthen the willingness to implement in new communities. Thus, evidence could be developed through practical experience in pilot communities.

Relative Advantage

The participants expressed a need for results or feedback on their efforts with IFS. Since this is lacking, it can be difficult to see the relative advantage with this type of intervention compared to allocating resources to other preventative activities. The development of IFS is also a task that differs from that of traditional FRS activities, and might not align with what these organisations consider to be their role in society, and therefore not align with available resources. The fact that the FRS lack a direct line of entry to home settings reinforces the difficulty in seeing the relative advantage of working with IFS for the elderly persons in their homes, relative to allocating resources to, e.g. generic dialogue with pensioner organizations.

Adaptability

The developed methods for IFS varied from information to elderly people in general, to specific home visits among single individuals in risk groups, indicating a high level of adaptability. Several ways of identifying risk individuals were also described. Firstly, emergency call-outs can present encounters with risk individuals that can be offered relevant information concerning IFS. Secondly, knocking on doors in identified geographical risk areas is another option, and thirdly, cooperation with social and health services can be used to identify risk behaviour among individuals already using municipal home care.

Trialability

All of the participants emphasised the importance of incremental implementation and a need to be able to try different modes of intervention in order to be successful. In one of the municipalities, the FRS and the social services collaborated to develop the IFS intervention in a pilot-project, which resulted in a successful trial and political approval to continue the implementation of IFS. In another municipality within the same fire service federation, resistance had been met to the implementation of IFS historically; but the participant thought that there would be a more open attitude to future efforts given the successful implementation in a neighbouring municipality in the same fire service federation.

Complexity

The decision making structures described in Figure 2 give an indication of the complexity inherent in designing and implementing IFS in any given community in Sweden. Identification of who is responsible for the implementation is at times difficult. As one participant stated, the FRS understands the technical issues, knows the fire safety problem and sees the benefit of IFS. At the same time the FRS is the smallest administrative unit in the municipality and needs to convince social services, the largest administrative unit in the municipality, of the benefit and need for IFS in competition with other pressing needs for these risk groups, e.g. basic hygiene and nutrition. Apart from providing basic care and medical assistance, there are also demands on social services for regular quality development, such as the need to alleviate fall risks. In some municipalities there was a strong working relationship between the FRS and the social services, in others this relationship was weak. The difficulty in implementation depended highly on the specific conditions and networks in the areas.

Design Quality & Packaging

The success of an intervention appears to be dependent on how the information is delivered, although there is no systematic information available concerning which specific types of contact work best. This translates to a lack of experiential information concerning best practices, e.g. content in written information or personal contact to at risk individuals. In one municipality, the lack of staffing resulted in identified risk individuals being provided with written information and recommendations only, while in another municipality there was an effort to book follow-up visits after a fire incident with both the social services and FRS present to provide weight to the recommendations offered.

Design quality and packaging seems to improve as IFS is implemented in one community and then moved to another for further implementation. Lessons learned and success stories from a nearby municipality appear to act as a role model.

Cost

Local government finances are typically strained. Several interviews revealed that there is often broad acceptance of the value of IFS, provided its implementation does not entail any additional cost. The social service sector is interested in IFS and does see the need for it; but interviewed participants from the FRS reported that lack of implementation is typically blamed on lack of resources. In one municipality the participant stated that "*The common theme behind lack of implementation is that this costs work hours, and most importantly that technical solutions cost money*." Another recognised the question of which part of the municipality is responsible for the implementation of IFS is also driven by costs and budgets, "*If the FRS is not able to implement IFS then there is no funding in social services for this."*

If funding is needed, e.g. for additional time for care professionals to deploy additional checklists, or for the installation of technical systems, this can be a significant barrier to implementation. Low cost technical systems, e.g. fire blankets, fire resistant sheets and bedding, fire resistant aprons for smokers, fire detectors and fire extinguishers must typically be paid for by the residents themselves. More expensive technical systems, e.g. stove guards can be funded via the Housing Adaptation Grant Act (SFS2018:222) or mobile water mist systems can be covered by local government funding; but this requires the client to go through an application process which may or may not be facilitated by the municipality itself. As a possible solution, one participant suggested the construction of a special fund with allocated funding from both the FRS and social services, which could cover the costs.

Outer Setting

Client Needs & Resources

The division of responsibilities leads to a fragmented understanding of client needs and fragmented control of available resources. The FRS has responsibility for fire safety of citizens while social service is responsible for elderly people in need of social service. The introduction of new routines by the FRS for home care personnel concerning IFS, can only be implemented after agreement with the social services, it cannot be mandated by the FRS alone. The use of resources is therefore highly related to the topic of *Cosmopolitanism* according to CFIR, or established external networks and collaboration between different stakeholders providing support for risk groups.

Full understanding of the needs of individuals within identified risk groups requires a multifaceted dialogue between various stakeholders, which also involves the clients. Most elderly people are happy to receive help; but some, quite often those exhibiting significant risk behaviour such as heavy smoking or people with high alcohol consumption, refuse to modify their behaviour to alleviate identified risks. The Patient's Rights Act (SFS2014:821), which supports the personal integrity and self-determination of the patient, was acknowledged by participants as something positive; but, they also expressed some frustration that it could provide a barrier to reducing risk if the person did not want any help. Indeed, participants acknowledged that the person who opens the door when they knock on doors in risk neighbourhoods are often not those most in need of help. In many cases the home care providers identify risks in patients

homes, but they are unable to alleviate these risks as risk behaviour is highly entrenched, e.g. storing food in the oven, having flammable material close to source of ignition, smoking in bed and alcohol consumption.

One poignant example concerns the elderly person interviewed in their home who had experienced a fire. The elderly person explained that she had started to smoke when her husband died. She always smoke after eating and she uses smoking as a reward when she has done something positive. She was not motivated to quit and was in the habit of smoking in the kitchen sitting on a chair with a pad in front of the stove, although sometimes she smokes outdoors. One evening she fell asleep while smoking, after taking a sleeping pill and woke up from the fire alarm and pressed her service alarm. The social service could call the FRS and the social service arrived quickly and helped her out. The service personnel informed the elderly resident and suggested changes, but the resident must decide themselves, which changes to make to improve their personal safety.

Cosmopolitanism

In order to succeed with the interventions, the participants described how important it was to have well established networks and to identify the right persons in the municipalities' home care, associations for senior citizens, or other organisations with large participation of elderly people. In one municipality, the FRS previously received information from social service managers about different types of fire safety measures. However, this is presently not prioritized in the political organization, and therefore no regular dialogue exists to support of the multi-facetted needs of home care patients.

In one municipality where the FRS had a dedicated senior consultant employed, collaboration with the social service managers was ongoing to ensure broad support of elderly people in the community. The Senior Consultant also tried to approach organisations providing accommodation aimed for people 55 years or older, and to develop a dialogue with the municipal Guardian Committee which supervise legal guardians who support citizens who for some reason are deemed unfit to make executive decisions for themselves. The Guardian Committee provides a direct point of contact with legal guardians who have regular contact with and make financial decisions for some particularly frail elderly persons. The existence and development of these networks and others in the community are key to the successful implementation of IFS.

Peer pressure

The participants indicated an active interest in interventions taking place in neighbouring communities. Some referred to the fact that successful interventions in one municipality provided inspiration for initiating implementation of a similar intervention in another municipality. On a broader scale, the coalition of fire chiefs signing the so called Karlstad Agreement in 2016 shows a commitment to develop IFS in their communities, bolstered by peer pressure [33]. This peer pressure within the FRS community can also be used to leverage political peer pressure.

Some of the participants described that the process to implement IFS had started several years before, but that they had faced challenges to implement planned interventions, leading to a feeling of failure to support risk groups in their community. Some representatives of the FRS reflected that it is easier to implement an intervention when somebody asks for it. For example, when the home care professionals ask

for support to implement IFS after they had heard about it from other municipalities they are much more receptive to input from the FRS than when the impetus for implementation comes from the FRS directly.

External policy & incentives

This attribute is a broad collection of external strategies (governmental or other) in support of the development of the intervention. In this sense, both the Karlstad Agreement [33] and local policies or guidelines in support of IFS provide a necessary backdrop to successful implementation. The vision zero policy for fire deaths as defined by MSB [20] and associated guidelines specifically for home settings [26] provide strong policy support for IFS. Legal support can also be gleaned from the Civil Protection Action (SFS2003:778), the Social Services Act (SFS2001:453), the Health and Medical Services Act (SFS2017:30), the House Adaptation Grant Act (SFS2018:222) and the Patients' Rights Act (SFS2014:821), which all provide necessary input into the development of IFS in a community. There is significant support for implementation through this attribute.

In contrast to other policy support, client confidentiality can provide some barriers to implementation of IFS due to difficulties in identifying risk individuals. This can be circumvented by identifying risk areas in towns or cities as opposed to risk individuals. The strength of the Civil Protection Act relative to other legal protection of patient's rights is unclear leading to additional uncertainty concerning the mandate of the FRS to act.

Inner setting

Structural characteristics

The need for structural change in support of new practices with in the FRS, e.g. the implementation of IFS, is reinforced by identification of the need for a change agent, someone that leads the way, in certain interviews. The presence of dedicated positions helps to elevate the standing of the intervention by building organizational memory of IFS interventions. In contrast, in the absence of dedicated positions, movement of personnel from one project or position in an organization to another means a loss of organizational memory and undermines the understanding of IFS.

Networks and communications

An obstacle to implementing and maintaining IFS, raised by the participants, is the lack of formal channels of communication between actors within the municipality. To successfully implement IFS, there is a need, e.g. for improved communications between FRS and the social services.

Cooperation depends on individual engagement and the participants perceive that it is up to them to create networks, both inside and outside the municipality. One example of successful networking and communication is the organisation of the much appreciated "safety days" together with pensioner organizations, where fire protection is discussed, together with other safety and health matters. The lack of established networks and lack of clear communication guidelines can be a hinder to successful implementation of IFS.

Culture

The FRS have a long and proud history, and the norms and values that have developed over time can be difficult to change, which means that there can be some internal resistance to preventative safety activities in general and IFS specifically. As one participant from the FRS noted *"[The FRS] is a corp that has not been reformed. There is a strong professional trade union. The firefighters typically unite against change."* Staff turnover is low and personnel are quickly socialised according to existing norms and values. Another participant from the FRS noted that *"those who are new to the profession are rapidly indoctrinated […] and it is a major challenge to break established patterns of behaviour."* A cultural development to expand the traditional role of the FRS to include preventative activities such as IFS has been occurring over the past decade or more, but cultural barriers to preventative activities may still exist and potentially impact on the implementation of IFS.

Implementation climate

The participants expressed a view that IFS is not implemented as it ought to be and acknowledged the need for tools to increase fire prevention for risk groups. However, it might not be possible for all stakeholders to prioritise fire prevention. The social services often lack the time to e.g. identify risk individuals; and there is no clear culture of dialogue with the FRS, so they are not considered a resource for the social services to draw on. One way to bridge the gap between FRS and social services can be by having people within the FRS with educational background or experience from social services or health care. At the same time, if cooperation is dependent on a specific individual this can be a weak link in implementation.

Readiness for implementation

Even though there is an awareness of the problem within the FRS, prevalence of fatal fires are low and the stakeholders might not perceive the situation as intolerable. A rare firsthand experience contributes to not perceiving the problem as urgent, which can hinder implementation.

Further, there is a perception that the agenda of key stakeholders do not align, and that it is difficult to include all perspectives and needs in home care. From the perspective of the FRS it is reasonable to expect the social services to have a checklist for fire prevention, but from the perspective of the social services this is not necessarily a prioritised task. As one participant stated "*It is difficult to see all perspectives, my priorities are closest to heart*."

Characteristics of individuals

Knowledge and beliefs about the intervention

IFS has been a topic of interest for approximately seven years in Sweden. The Local Government Act (SFS 2017:725) means that each municipality has a mandate to determine and prioritize many activities at a local level. In one interview it was suggested that the FRS needs to improve their knowledge of home care in order to be able to tailor IFS to the actual situation in the homes of risk individuals. Many FRS have limited experience of preventative fire safety or home visits. The development of guidelines in some municipalities is helping to alleviate some of the problems of knowledge and understanding of the intervention, which can also have a positive impact on beliefs concerning the intervention. As one participant stated, "*It is important to scale down ambitions to a relatively low level so that they will be doable and realistic.*" Central coordination is necessary, as are local champions to ensure implementation.

Self-efficacy

Putting out fires and assisting at traffic accident sites are looked upon as the primary process for the FRS, and the interviews show that preventative work is considered more of a complementary process. The operative rescue service personnel might not see preventative work as a part of their role, and it can be a task that they feel less equipped to handle. This lack of self-efficacy regarding the ability to take an active role in prevention is highlighted as an obstacle, and an area where confidence and knowledge need to improve. Participants explained that firefighters are also indoctrinated in the need to work in groups or "squads". Preventative work, such as the implementation of IFS, is typically done by single change agents, which can be seen to be in conflict with the group imperatives. Preventative positions have low status, leading lone firefighters in this field to be potentially uncertain of their role both in society and in their organisations. As one participant stated: *"Personnel de-value themselves. Alone is uncertain. They do not understand what they symbolize and what they can achieve. They do not understand their own power, what they represent and what they can influence. In contrast to the police, where police just go in, throw themselves into situations, firefighters hesitate. Firefighters are uncertain of their role if there is no fire."*

Individual stage of change

Firefighters are sometimes hesitant about conducting home visits. They do not see the need in their context. Coupled to the fact that there is no immediate feedback concerning the success of the action, i.e. no fire is extinguished, no-one is obviously saved. There is a need to reinforce the value of preventative activities. Individuals who see the value of preventing a fire as opposed to extinguishing the fire are typically further along on the path to understanding the need for changes in the way we create fire safety for risk groups. In cases where there is a dedicated position responsible for the implementation of IFS or working with risk groups it is more common that the individual responsible for the implementation of IFS has a well-developed stage of change.

Individual identification with organization

As stated previously, the firefighter union is typically strong and participants reported that firefighters are rapidly indoctrinated into existing culture. The individuals typically identify strongly with their colleagues and their team or squad members rather than necessarily with their organization. In this case, backing from senior management is important to break potential informal structures in the organisation and strengthen the organisation itself. Individuals that are a part of the core management are more likely to identify with the organisation than operative personnel. Therefore, the creation of bespoke positions within the organisation with a clear mandate to work on IFS increases the likelihood that individuals will identify with the priorities of the organisation rather than that of individual teams or informal groups within the organisation.

Other personal attributes

Several participants pointed out that an inherent difficulty with IFS is identifying and reaching risk-individuals. When identified, the challenge is reaching risk individuals and motivating them to receive

advice and make changes to improve fire safety. When knocking on doors, there is a perception that risk individuals are not the ones that are willing to open and receive advice. There is often a certain amount of resistance to approaching the public about risk behaviour. In one interview it was stated that *"In the beginning I found it difficult to know what to say so that people we approached would not react in a defensive manner, that they don't appreciate someone ringing on their door and complaining about their behaviour."* Once the participants had developed a methodology, they felt that the visits were typically seen as something positive by the residents. They emphasised the importance of, e.g. having staff that could communicate in foreign languages when approaching immigrants.

Process

Planning

The IFS intervention is more of a concept than a fixed method. This opens up for innovation within the concept, and the organizations need to develop the practical procedures. As part of this process, the FRS often look at how others have made similar interventions and draw inspiration for previous experiences. The planning process is supported by peer recommendations, referring to the success of others promotes implementation which is an advantage in seeking acceptance within the organization. Through stepwise implementation, and at the same time pointing to the success of others, implementation is facilitated.

All of the participants emphasised how the heavy workload within the health care organization affects implementation. Despite being interested, working with IFS tends to drown in day-to-day tasks. In one case it was stated that *"The home care staff think that it has been interesting to work with the question of individualized fire safety but the organization needs to include this work as part of the planned activities, otherwise it tends not to happen."*

It is important to recognise this need and incorporate IFS into other existing processes. In one case the implementation into existing routines had been recognized: *"We have recently finished a pilot project and will begin working with IFS outside of the project format. We have developed a strategy, the home care-givers have a checklist for biennial risk rounds (scheduled in April and October each year). This timing has been chosen to suit when two other checklists are followed (one for occupational risks and one for cognitive ability)."*

When combining IFS with other quality and prevention work, it becomes time effective and easily remembered. Additionally, the addressed matters can be linked to the same problems, e.g. identifying and mitigating initial memory loss problems and decreases the risk of fire as well as malnutrition and fall risk.

Engaging

The interviews often highlighted the importance of attracting and involving appropriate individuals in the implementation. Without sufficient political and organisational buy-in for the idea of IFS there would be no real momentum behind its implementation. Some participants talked about the need for champions and/or bespoke positions within the organisation rather than projects that come and go depending on short term priorities.

In one municipality, a pilot project concerning IFS had been tried previously but was found to succeed only when the right individuals from both the FRS and social services connected and could drive the

implementation from various parts within the municipality. Once a successful outcome had been achieved, these committed individuals could provide a basis for engaging further decision makers to ensure that the project became institutionalised by creating routines.

Similarly, in those cases where municipalities described challenges to the implementation of IFS this was typically due to the difficulty of identifying key individuals and convincing them of the need for its implementation. Results show that there is often an officially appointed person leading the implementation of IFS, even though this person might also have other responsibilities, and divide their time between various tasks.

Executing

Execution of IFS is often a question of responsibility. Who is responsible, the FRS, social services or the individual? As one participant stated *"When we consider individual houses, the regulations say that fire safety is the responsibility of the home owner. Should we charge a person with dementia because they do not have sufficient fire safety? We have considered it but it does seem inhuman given the situation."*

Some of the FRS interpreted it as their responsibility to organize the IFS within their own organization, whereas in one organization it was decided that the home care would carry out the IFS when the intervention was fully developed but that it would be developed jointly by the FRS and social services together.

If the FRS or social services take responsibility there is a risk that cases remain unresolved due to lack of time. Prioritisation is difficult when basic health and safety needs must be prioritized over the risk of relatively rare fire events. Prioritisation is also continually changing. As one participant noted, they were in the starting blocks for implementing IFS when COVID-19 arrived and used up all available resources.

In the researched organisations, the length of the decision process needed for execution varied. Independent of whether the organisation was small or consisted of several municipalities, execution of IFS typically started small, e.g. in one geographical area. Implementation in small scale made it easier to make the decisions and involve stakeholders, and lessons learnt in a limited setting could then be translated into a larger scale implementation.

Reflecting and evaluating

The results clearly show that when it comes to IFS, a full feedback loop is seldom in place. This is true both at the organisational and case specific level. One reason is lack of time, but there is also a lack of recognition of the importance of reflection and evaluation. When personnel are few and tasks are many, there is seldom room to take the time to reflect on or evaluate various interventions. In particular, very little time appears to be allocated to return visits to investigate whether recommended IFS has actually been put into practice.

The lack of follow up on preventative measures is mentioned as a key obstacle for the implementation. Preventative work is perceived as abstract, as it is hard to see an immediate effect, and compared to the core task of the FRS, like putting out fires, the effects are vague. The need for follow ups as a way to increase motivation for prevention is highlighted. Further, it is difficult to measure the effect of implementation which discourages introspection and evaluation.

Discussion

In this study we have explored the barriers and facilitators for implementation of IFS interventions in Swedish municipalities, using the CFIR as a tool for analysis. Individualised fire safety has been a topic of interest from a national level for a relatively short time period, and as each municipality has the mandate to determine and prioritize activities at a local level, it has far from reached full implementation as yet. The fact that IFS is not a fixed intervention, leaves room for a high degree of innovation, but also some room for frustration due to uncertainty concerning best practices. In this study, the results show that the general features of the interventions can be grouped into three main types, indicating a high level of adaptability. The three types of interventions focus on 1) the single individuals at risk, 2) identified groups at risk or 3) identified geographical areas at risk. The CFIR framework developed within the health care sector provides an opportunity to identify several facilitators and barriers for implementation of IFS interventions within these different types of IFS intervention.

Types of IFS intervention

Single individuals are always the target for IFS, but the types of IFS interventions were found to exhibit clear differences in how these individuals were identified and approached. Using one type of intervention in an organisation does not necessarily exclude another as they can be combined. For example, preventive interventions in geographical areas at risk can be done at the same time as there is a program for single individuals who have been identified as being at risk.

1) IFS intervention – single individuals at risk. In certain municipalities, specific individuals with risk behaviour were identified by social services as appropriate for IFS in their community. These individuals were then approached and evaluated to identify the best solution for their specific needs. For elderly people with increased risk of fire, a variety of relevant interventions have been implemented in such cases. These include, i) checklists employed during home visits by healthcare personnel, ii) outreach through specialised information (including printed and internet based), and iii) the installation of technical aids to improve passive and active fire protection. Checklists have been developed typically through collaboration between the fire services and home care professionals. Ideally, the check lists were included in established routines for annual client evaluation to ensure that up to date evaluations were made regularly. Outreach included, e.g. an informative YouTube video tailored to municipalities and citizens alike [34]. Technical aids included stove guards, individualized fire sprinklers and fire safety alarms interconnected with personal safety alarms for elderly people. In most cases, the cost of such technical aids were covered by the local municipality directly or by means of housing adaptation grants to facilitate their handling and installation. If deemed necessary, a plan for how to increase fire safety could be established and technical systems identified and installed.

2) IFS intervention – identifying groups at risk. In certain municipalities, specific groups were identified as at risk, and initial contact was with this group, independent of the needs of the specific individuals within the group. The organizations working at this level typically had a position with a specific responsibility for the IFS intervention, which ensured continuity and facilitated the development of clear best practice and local guidelines. As one participant expressed, should that person change jobs, the implementation of IFS would continue as the position would be filled by a new recruit. In communities with this level of implementation, checklists were developed but were not necessarily connected to home care. General contact could then be supplemented by follow-up phone calls and/or home visits.

At follow-up home visits, the fire service staff would give advice about fire safety and technical solutions, such as stove guards and fire blankets, about routines for replacing batteries in the fire alarm and the risk associated with e.g. storing flammable material, on or in the stove. In cases when elderly people might have difficulties to reach the fire alarm and testing the battery, the fire services might suggest that children or friends could do this every year, e.g. before Christmas or when visiting in conjunction with a birthday. Due to personal integrity, however, all technical solutions were presented as options together with how to apply for support for installation, but the client was required to be active in applying for implementation of such solutions. No bespoke solution was developed for the individuals rather general recommendations were given for the group.

3) IFS intervention – identified geographical areas at risk. At this level of IFS, the rescue services identified geographical areas which were found to exhibit a heightened risk at a general level and try to reach individuals in high risk areas rather than specifically targeting high risk persons. In one example of preventative intervention in a high risk geographical area, representatives from the fire services gave advance notification of home visits in specific areas, asking about home fire safety and offering advice to decrease risk. In one municipality, for example, special attention was placed on apartment buildings in risk areas.

The thinking in this case is that it is effective to target a neighbourhood with low socioeconomic conditions where the problems are "clustered". On the other hand, this type of intervention tends to miss the most vulnerable individuals. Passive prevention is probably effective in these neighbourhoods, but to reach frail elderly requires cooperation between organisations that are in regular contact with this population specifically with tailored information.

Facilitators and barriers for success for IFS

In this study we identified a number of barriers and facilitators for implementation of IFS interventions in Swedish municipalities. Table 2 provides an overview of these, and in this section we discuss the prospects for broader implementation of IFS.

The results show that, as an intervention, IFS has characteristics that potentially facilitate implementation, e.g. a high level of *trialability* and *adaptability*, where the possibility to start small and adapt to local circumstances are frequently used. Another example is that the policy document which is at the heart of IFS is both appreciated and needed, and results show that authority guidelines, and national initiatives play an important role in the implementation of IFS with great symbolic value, in particular for the FRS. However, one of the major barriers to implementation is also linked to the intervention characteristics, i.e. it is unclear where the responsibility for fire protection of vulnerable groups lays. In turn, this effects many aspects of implementation and hinders stakeholders from fully taking responsibility for developing and implementing IFS. This can further be linked to the issue of costs, as the lack of funds is highlighted as a significant barrier to implementation. Unfortunately, the question of cost is closely connected to difficulties for the health care sector and social services to allocation the needed resources in already strained organizations. The question of responsibility for implementation is inextricably tied to the question of cost as without clear resolution of responsibility, the cost is unlikely to be adequately included in annual budgets.

In order to successfully implement IFS, cross-sectoral cooperation between health care and social service organizations and the FRS, is crucial. Although there is general agreement that IFS is needed, collaboration is challenging, both to organize and maintain. According to the FRS, the main obstacle is the lack of resources to prioritize IFS within health care and social services. Preventing the risk of fire, a relatively rare problem, is only one of many important tasks, and is therefore often set aside. Similar

problems were identified by Halvorsen et al. [35], who studied fire safety for vulnerable groups in Norway. The results of the present study indicate the need for a deeper mutual understanding of the problem, and to integrate IFS into regular work routines. One suggestion was to include standards for IFS in the procurement phase of home care service planning, to ensure that home care providers planned to include this aspect of home care from the outset. A key facilitator also seems to be designated positions within the FRS, preferably designed to include knowledge and/or experience from health care or social services, to bridge the gap and facilitate cooperation [36].

In the CFIR framework, the inner setting of organisational culture is emphasised as an aspect that effects implementation. In the current case, tradition and norms seem to stand in the way of change. Individualised fire safety is a relatively new task, a task that differs from the traditional role of FRS. Preventative work is not the primary process within the organization, and the FRS has a perceived lack of knowledge in this field. The need for change agents [28] is clearly stated in the results. When someone takes the lead, others can follow. It is not only on an individual level that there is a need for early adopters [30], also on an organisational level this seems beneficial. There is a tradition of experiential learning in the FRS [37], which can be exploited by using lessons learnt from successful implementation in one municipality to another. Regarding the process, starting small and gradually implementing IFS is, also a facilitator which potentially builds on this experiential tradition. In contrast, one barrier identified is the lack of follow up to specific activities. A closed feedback loop can be an effective facilitator [38], and developing indicators to measure effects are therefore important.

Lastly, a potential obstacle for implementation, just briefly covered in this study, is the risk groups perceived lack of need for fire protection, a factor often foreseen in implementation [28]. Vulnerable individuals, most in need for IFS, are often marginalized reflecting underlying social determinants of health [39]. After overcoming e.g. organizational barriers, and identification of risk individuals, the factor of motivation for change still remains [35], an aspects that need to be further explored.

Table 2. Identified barriers and facilitators presented by dimensions and attributes according the CFIR framework.

Dimensions	Attributes	Facilitators and barriers
Intervention characteristics	Intervention source	Need for clear guidelines locally, regionally and nationally.
	Evidence strength and quality	FRS acknowledge the problem but perception of evidence strength and quality sometimes weak.
	Relative advantage	Lacking due to scarce feedback on effects. IFS is an apart task for FRS.
	Adaptability	High, facilitates implementation.
	Trialability	High, pilots and incremental implementation is positive.
	Complexity	Responsibility unclear. IFS is competing with other pressing needs. Dependent on local networks.
	Design quality and packaging	Improving gradually. Success stories important.

	Cost	Costs vary, depending on type. Lack of funding a significant barrier. Unclear responsibility regarding additional costs.
Outer setting	Client needs and resources	Fragmented understanding and lacking resources. External networks crucial. Risk behaviour in target groups.
	Cosmopolitanism	Networks difficult to withhold
	Peer pressure	Occurs, successful examples inspires.
	External Policy and incentives	Legal support and policies largely in place. Somewhat contradicting policies.
Inner setting	Structural characteristic	Deep-rooted organisation with set norms and values.
	Networks and communications	Lack of communication and formal channels for cooperation.
	Culture	Need for new tools. Lacking time. FRS not seen as a resource.
	Implementation climate	Experience from social services in FRS, is helpful.
	Readiness for implementation	Vary. Fires are rare events, provides a barrier. Stakeholders have different agendas.
Characteristics of individuals	Knowledge and beliefs…	Perceived lack of knowledge. Experience is limited.
	Self-efficacy	Prevention not internalised in the FRS role. Lack of self-efficacy. Prevention has low status.
	Individual stage of change	Might not see the need. Hesitant to home visits.
	Individual identification with organisation	Weak identification with prevention as a significant duty.
	Other personal attributes	Strong culture norms and values provides barriers. Clear methods facilitate through increased confidence.
Process	Planning	Inspiration from others. Stepwise implementation. Start small. Incorporate IFS into existing processes.
	Engaging	Political and organisational support vital. Bespoke positions important. Pilot project drive implementation. Difficulty to identify key individuals in social services.
	Executing	Challenging to identify, reach and motivate risk-individuals. Responsibility needed, responsibility unclear. Lack of resources. Other needs more urgent.
	Reflecting and evaluating	Lack of follow up perceived as a key barrier. Prevention effect abstract.

Methodological reflections

In this study, matters concerning the implementation of IFS in Swedish municipalities have been qualitatively described. The CFIR framework was a helpful tool in structuring the data and describing the complex challenges and facilitators for implementation. However, the five dimensions and their underlying attributes are interlinked [28] and therefore some of the aspects appear more than once, anticipating to show the matter from different angles. The questions asked were open and not structured by the framework CFIR, which means that data could address additional aspects of the intervention [32], but during the coding process no new category emerged. The CFIR framework was originally developed for implementation of evidence-based health care interventions, but has also been used as a guide to understand other implementation processes (see e.g. [40-42]), reinforcing its broad potential for application.

Due to limitations in time and to the ongoing Covid-19 pandemic, we have focused on the perspective of the FRS. However, in terms of trustworthiness [32], the data was rich and similar issues were addressed in several of the interviews, complemented by secondary data. For example, in greater organizations, the examples given addressed single municipalities in the area, and they were similar to smaller organisations, indicating transferability. Although the major aspects of the problem probably are identified, to get a comprehensive view of the possibilities for implementing IFS among frail elderly people, the perspective of health care staff and care takers need to be deepened in future studies.

Conclusions

In this study, similarities and differences between Swedish IFS interventions were described as well as dimensions that offer support for or barriers to implementation of IFS. The general features of the IFS interventions are described as interventions focusing on 1) individuals at risk, 2) groups at risk and 3) geographical areas at risk. Using this division of interventions into three different types, it becomes clear that even municipalities without specific IFS action programs are working on IFS, starting at a general level but nonetheless ending up at an individualised dialogue of fire risk and risk prevention.

The CFIR framework proved to be a powerful tool to analyse the interventions studied and identify facilitators and barriers to successful implementation. While the framework has been developed to assess well-defined interventions, it has been suitable to analyse the situation of IFS despite the fact that there is no single, clearly defined methodology for its implementation. Indeed, our study indicates that there is no one size fits all approach to IFS, in particular in light of the complex structure of delegation of authority from national to local level in Sweden, coupled to broad differences in the size and governance of the FRS and home care services at local level; but that the CFIR framework provides a robust assessment methodology.

Some key facilitators, which can also be barriers if not achieved, include political support for IFS interventions, and funding. A barrier to implementation is the lack of clear definition of whether implementation of MSB's vision zero for fire deaths is the responsibility of the FRS or others. This latter barrier is also closely tied to the question of funding, as until the responsible authority can be determined it is unclear whose budget should include funding provisions. Despite this barrier, IFS is implemented in many municipalities in some way, and much positive action is being taken to ensure that risk groups, including but not limited to elderly persons, are given information and support to improve their personal

fire safety situation. Should existing barriers be relieved, however, and facilitators be leveraged, even more could be done for these groups in the future.

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The authors do not have any conflicts of interest regarding this study

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Code availability

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Authors' contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by jointly, as so the draft of the manuscript. All authors read and approved the final manuscript.

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