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AGENTI DI CLIMA E PERFORMANCE DI SICUREZZA: UN'ANALISI MULTILIVELLO

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Capitolo 1

Introduzione: Clima di sicurezza e performance di sicurezza

Premessa

Ogni giorno in Italia si verificano circa 2.500 incidenti sul lavoro (dati INAIL) e questo comporta mediamente la morte di 3 lavoratori al giorno e l'invalidità di 27. I dati del 2007 sembrano il bollettino di una guerra: circa 1.200 morti e 800.000 invalidi permanenti sul lavoro. Oltre ai costi sociali non vanno sottovalutati i costi economici di questo fenomeno: 45 miliardi di euro, circa il 3% del PIL. Negli anni successivi al 2007 si è registrato un calo complessivo di questi indicatori che tuttavia sembra maggiormente imputabile alla grave crisi che ha colpito l'economia italiana, e quindi al calo degli occupati e delle ore lavorate, più che ad un reale inversione di tendenza nel trend infortunistico. Esperti di diverse discipline, tra cui anche studiosi di psicologia delle organizzazioni, tentano di far fronte a questa drammatica situazione.

La questione della sicurezza nei luoghi di lavoro si è sviluppata a partire da approcci diversi, e alcuni autori classificano le diverse modalità anche in sequenze storiche (Hale e Hovden, 1998; Glendon, Clarke e McKenna, 2006; Hudson, 2007, Borys, Else e Leggett, 2009), con una prima fase che mette in luce maggiormente l'aspetto ingegneristico/tecnico, seguita da una fase in cui si sviluppa una attenzione alla componente umana e alla sua relazione con le macchine, per arrivare infine a sottolineare l'importanza di aspetti legati alla cultura organizzativa. Quest'ultimo approccio negli ultimi anni, a livello interazionale, ha mostrato un crescente sviluppo, evidenziando sempre di più il ruolo che il clima e la cultura di sicurezza assumono nell'accrescere la sicurezza nei luoghi di lavoro. A livello nazionale, inoltre, le recenti disposizioni legislative (D.lgs. 81/08 e seguenti) sottolineano la necessità di porre una maggiore attenzione ai fattori psico-sociali e organizzativi per il miglioramento della sicurezza nei luoghi di lavoro e per una maggiore tutela del benessere e della salute del lavoratore. Proprio a partire da tali considerazioni nasce questa ricerca, che si colloca appunto nel filone che studia le relazioni tra clima di sicurezza e *performance* di sicurezza, con un approfondimento che riguarda gli agenti che questo clima determinano. La ricerca prende in esame un particolare settore, quello metalmeccanico, che in Italia, dopo le costruzioni, negli ultimi anni ha registrato il maggior numero di incidenti ed infortuni nei luoghi di lavoro.

In questi ultimi anni il clima di sicurezza nelle organizzazioni è divenuto un argomento sempre più rilevante, sia dal punto di vista scientifico sia da quello applicativo, dal momento che se ne è riscontrata la capacità di influire sulla *performance* di sicurezza dei lavoratori. Esso si è nel tempo affermato in alternativa alla cultura di sicurezza – atteggiamenti, credo, percezioni e valori che i lavoratori condividono riguardo alla sicurezza (Cox e Cox, 1991) – in quanto più facilmente misurabile (Cox & Flin, 1998; Hale, 2000; Guldenmund, 2000). Negli ultimi dieci anni molti ricercatori si sono concentrati a studiare la capacità predittiva del clima di sicurezza rispetto alla performance di sicurezza (e.g. Zohar, 2000, Zohar & Luria, 2005; Clarke, 2006; Griffin & Neal, 2000; Nahrgang, Morgeson & Hofmann, 2007; Christian, Bradley, Wallace, & Burke, 2009). Christian et al. (2009) nel loro lavoro meta-analitico identificano il clima come *leading indicator* della performance di sicurezza e buon predittore anche degli outcome di sicurezza oggetti. A partire da uno studio approfondito della letteratura, propongono uno schema concettuale integrato per spiegare l'influenza di fattori distali situazionali e personali sulla performance e sugli outcome di sicurezza.

Nonostante questi risultati, a partire dalle rassegne e dagli studi meta-analitici disponibili, Zohar (2010a) evidenzia come ci siano tuttavia ancora alcune questioni aperte riguardo allo studio del clima di sicurezza, sia dal punto di vista concettuale sia dal punto di vista metodologico. Dal punto di vista concettuale egli sottolinea ad esempio l'uso indistinto dei concetti di clima e di cultura di sicurezza, e dei relativi strumenti di misura, e la confusione nel definire cosa sia clima e quali siano le dimensioni da cui esso è caratterizzato. Dal punto di vista metodologico, egli mette in evidenza ad esempio l'ambiguità nella scelta di item che a volte confondono i livelli di analisi, e l'uso di metodi di analisi che non sempre tengono conto del carattere multilivello dei dati riguardanti il clima di sicurezza. A tale proposito Zohar (2010b, p.1521) afferma che "*Given that the target of climate perceptions can relate to organization or group levels of analysis (i.e. senior management commitments and policies vs. supervisory or co-worker practices), it follows that climate measurement should be based on level-adjusted subscales offering separate measures for climates associated with respective organizational levels. [...] the practice of mixing items associated with divergent levels of analysis must be discontinued in order to avoid level discrepancy errors in safety climate measurement.*"[1] Tale riflessione non riguarda solo il problema della chiarezza relativa al livello

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[1]"Dal momento che l'oggetto delle percezioni di clima può essere riferito al livello di analisi relativo all'organizzazione o a quello di gruppo di lavoro (i.e. commitment e politiche della direzione aziendale vs pratiche dei supervisori o dei colleghi), ne consegue che la misurazione del clima dovrebbe essere basata su sotto-scale

in cui si rilevano le percezioni di clima: Shannon & Norman (2009) sottolineano come sia importante che, se i dati raccolti sono per loro natura multilivello, essi devono essere anche analizzati con metodi adeguati a tale caratteristica.

Accanto alla questione di cosa sia il clima di sicurezza, e di quali siano le caratteristiche di tale costrutto (cfr. anche Griffin & Neal, 2000), nonché alla necessità di considerarne la dimensione multilivello, sia in termini concettuali che in termini di analisi dei dati, una terza questione è quella degli agenti del clima. Secondo alcuni autori, infatti, nel momento in cui si prende in considerazione il clima a livello di gruppo di lavoro, non è sufficiente considerare soltanto il diretto supervisore: gli stessi colleghi che che fanno parte del gruppo hanno una forte influenza sui comportamenti dei singoli lavoratori (e.g. Melià, Mearns, Silva & Lima, 2008)

Alla luce di queste riflessioni, è nato questo lavoro, che si propone in primo luogo di offrire un strumento integrato per la rilevazione del clima di sicurezza, che tenti di tenere in considerazione gli interrogativi ancora aperti, integrando e combinando gli sguardi di diversi autori su tale argomento, in particolare di Melià (e.g. Melià, 1998, 2002; Melià & Sesè, 2007; Melià et al., 2008), di Zohar (e.g. 1980, 2000, 2010a, 2010c; Zohar & Luria, 2005) e di Griffin & Neal (Griffin & Neal, 2000; Neal & Griffin 2000, 2002, 2004; Neal, Griffin & Hart, 2000).

Innanzitutto, si tratta di uno strumento che tiene in considerazione in modo chiaro i diversi livelli in cui il clima si può e si deve misurare (organizzativo e di gruppo, e, in relazione

adattate ai vari livelli, che offrano misure distinte per i vari climi associati a diversi livelli di analisi. […] La pratica di mescolare item associati a diversi livelli di analisi deve essere fermata per evitare, nella misurazione del clima, errori legati alla differenza tra livelli."

alla dimensione di gruppo, con attenzione al supervisore e con attenzione ai colleghi di lavoro) con l'introduzione della misurazione del clima dei colleghi di lavoro accanto a quello dei classici referenti del clima, quali la direzione aziendale e i preposti.

In secondo luogo, tale strumento vuole essere attento anche alle specifiche dimensioni del clima di sicurezza (Griffin & Neal, 2000), così da non essere privato di quelle sfumature che possono renderlo anche un concreto mezzo diagnostico per costruire interventi migliorativi mirati e quindi maggiormente efficaci.

Un terza attenzione che ha guidato la costruzione di tale strumento è stata quella, così come viene suggerito dallo stesso Zohar (2010c), che esso non fosse generico, ma fosse definito e predisposto per essere utilizzato in uno specifico settore e per una particolare fascia di lavoratori: lo strumento costruito attraverso questa ricerca si occupa in particolare di misurare il clima di sicurezza dei lavoratori impiegati in produzione nella realtà delle imprese del settore metalmeccanico.

Questi obiettivi vengono portato avanti con una attenzione statistico-metodologica che fino ad oggi si è rilevata, solo occasionalmente nella letteratura studiata, ovvero attraverso l'uso di una analisi confermativa multilivello, che appunto sia attenta alla struttura gerarchica dei dati considerati (Shannon & Norman, 2009).

La presente ricerca non si ferma, tuttavia, all'aspetto della validazione di tale originale strumento di misura del clima di sicurezza. Un secondo obiettivo, presentato in un secondo studio, è quello di esplorare la relazione tra il sistema di clima di sicurezza centrato sugli agenti di clima e i comportamenti di sicurezza. Si partirà dunque dal modello definito da Zohar (Zohar & Luria, 2005) e da quello proposto da Melià e i suoi collaboratori (Melià et al., 2008), per verificare il ruolo di mediazione svolto dal clima di sicurezza relativo ai colleghi di lavoro nei confronti di due relazioni già consolidate in letteratura: quella tra clima di sicurezza organizzativo e performance di sicurezza, e quella tra clima di sicurezza relativo ai preposti e performance di sicurezza. Lo studio di tale modello e di tale effetto di mediazione sarà condotto sempre non dimenticando la struttura gerarchica dei dati, e quindi utilizzando un modello di equazioni strutturali multilivello.

Infine, un terzo obiettivo, presentato in un terzo studio, sarà quello di testare il modello concettuale proposto da Griffin & Neal (2000) e successivamente verificato attraverso il lavoro meta-analitico di Christian et al. (2009), che considera anche le determinanti dei comportamenti di sicurezza, ovvero motivazione e conoscenza, come mediatori della relazione tra clima e performance di sicurezza. La novità consiste nell'ampliare questo modello a partire dalla consapevolezza della molteplicità degli agenti di clima: il modello viene cioè integrato con l'aggiunta delle specificazioni dei diversi climi, in un sistema di relazioni che è quello verificato nello studio precedente. Sempre attraverso l'uso di tecniche di analisi dei dati multilivello, verrà verificata la capacità predittiva del modello così integrato, rispetto alla performance di sicurezza, e agli outcome di sicurezza, valutati specificamente come infortuni e microincidenti self-report.

L'intero percorso ha coinvolto nel suo complesso 10 aziende del settore metalmeccanico del Veneto, suddivise tra piccole, medie e grandi, per un totale di 1705 lavoratori in produzione o attività affini (l'83,2% degli operai impiegati in tali aziende).

Il clima di sicurezza

Breve excursus storico

Il clima di sicurezza inizia ad essere oggetto di ricerca in psicologia delle organizzazioni attorno agli anni ’50. In particolare, Keenan, Kerr e Sherman (1951) mettono in relazione il “clima psicologico” e l’ambiente fisico con il tasso di incidenti in ambiente di lavoro, rilevando che i fattori organizzativi hanno un’incidenza sugli infortuni a prescindere dal livello di rischio derivante dall’ambiente fisico. Tuttavia è solo negli anni settanta e ottanta che si ridesta l'interesse verso il clima di sicurezza, a causa della crescente attenzione dedicata ai concetti di cultura organizzativa e di clima organizzativo. Molti studiosi si concentrano sullo studio di questi due costrutti e su ciò che li differenzia (James & Jones, 1974; Schneider, 1975; Glick, 1985; Schein, 1992).

Schneider (1975) definisce il clima in termini di percezioni di pratiche organizzative, distinguendolo dalle reazioni alle medesime pratiche e procedure, e tuttavia conclude ammettendo la difficoltà di distinguere tra clima e cultura organizzativa. Glick (1985) afferma che la distinzione profonda tra questi due costrutti sta nelle discipline a cui afferiscono: mentre il clima organizzativo si è sviluppato primariamente nell'ambito di una cornice psicologico-sociale, la cultura organizzativa è profondamente radicata in ambito antropologico.

A questi temi ed in particolare agli studi sul clima organizzativo di Schneider (1975) si ispira il lavoro di Zohar del 1980, che focalizza nuovamente l'attenzione sul clima di sicurezza inteso come un aspetto del clima organizzativo specificamente riferito alla sicurezza nei luoghi di lavoro. Zohar (1980, p. 96) definisce il clima di sicurezza come "*a summary of molar* *perceptions that employees share about their work environments [...], a frame of reference for guiding appropriate and adaptive task behaviours*"[2]. Egli propone una prima misura del clima di sicurezza organizzativo composta di 40 item e testata su un campione di imprese industriali israeliane, evidenziando come il clima di sicurezza possa essere considerato una caratteristica delle organizzazioni industriali e come il grado di commitment del management di un impresa riguardo alla sicurezza contribuisca a determinare il successo dei programmi riguardanti la sicurezza in essa implementati.

Tuttavia negli anni successivi sono pochissimi gli studi pubblicati sul clima di sicurezza (Glennon, 1982a, 1982b; Brown & Holmes, 1986; IAEA, 1986). Nel grafico seguente (figura 1.1), tratto dalla rassegna di Glendon (2008), viene illustrato il trend dello sviluppo degli studi in questo ambito, presentando per ogni anno i lavori pubblicati in lingua inglese riguardanti il clima e la cultura di sicurezza dal 1980 al 2007.

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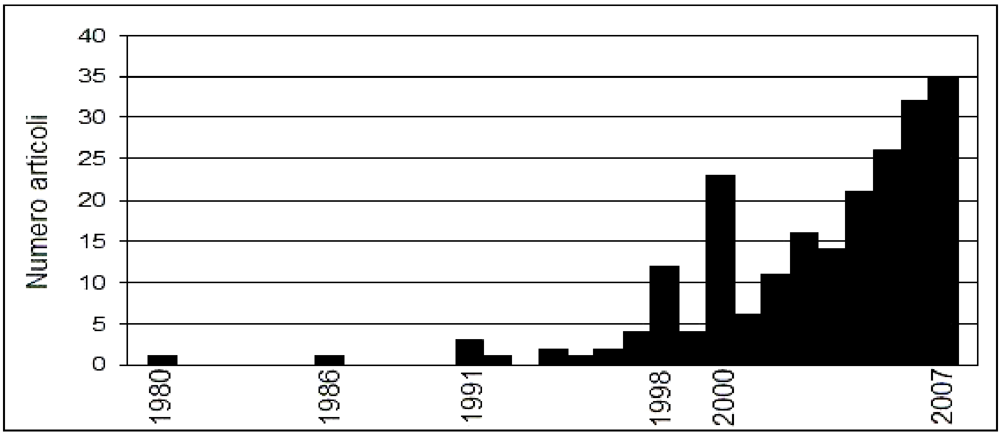

Figura 1.1. Articoli pubblicati dal 1980 al 2007 su clima e cultura di sicurezza (da Glendon, 2008)

[2]"una somma di percezioni molari che i lavoratori condividono circa i loro ambienti di lavoro [...], un quadro di riferimento che serve da guida per comportamenti appropriati e adattivi rispetto al compito".

È interessante notare come solo dopo la prima metà degli anni novanta la ricerca riguardo al clima di sicurezza incomincia a svilupparsi, in concomitanza con la pubblicazione dei rapporti dell'International Atomic Energy Agency sul disastro di Chernobyl (IAEA, 1986, 1991) che identificarono come fattore cruciale nell'incidente la scarsa cultura di sicurezza presente nella Centrale atomica.

Negli anni successivi gli studi sul clima e sulla cultura di sicurezza si moltiplicano fino a crescere con ritmi esponenziali nella prima decade del nuovo millennio. Negli stessi anni molte sono anche le rassegne e le meta-analisi che vengono pubblicate. In particolare sul clima di sicurezza si ricordano ad esempio le rassegne di Williamson, Feyer, Cairns & Biancotti (1997), di Guldemund (2000), di Flin, Mearns, O'Connor & Bryden (2000). Questi lavori mettono in evidenza come fino alla fine degli anni novanta la ricerca si sia concentrata su fini applicativi e su questioni di tipo metodologico più che sull'analisi del costrutto dal punto di vista teorico.

Inoltre, sempre da tali studi, emerge che la questione della validità degli strumenti utilizzati per misurare il clima di sicurezza non è considerata particolarmente rilevante. Decine di scale sono state create solo per l'industria manifatturiera, spesso facendo riferimento a dimensioni molto diverse da studio a studio. Williamson et al. (1997), negli studi da loro esaminati, trovano associate scale che misurano atteggiamenti con scale che si riferiscono a percezioni. Più studi, infatti, nel definire il clima di sicurezza fanno riferimento sia ad atteggiamenti che a percezioni, in alcuni casi sovrapponendo i due termini. Ad esempio, Coyle, Sleeman & Adams (1995) definiscono il clima di sicurezza come la misurazione oggettiva di atteggiamenti e percezioni riguardanti la salute sul lavoro e questioni legate alla sicurezza. A tale proposito qualche anno dopo, in uno studio meta-analitico, Clarke (2006a), tentando di fare chiarezza, distingue tre tipi di approcci: un approccio basato sugli atteggiamenti, un approccio percettivo e un approccio misto che combina atteggiamenti e percezioni. Inoltre evidenzia come l'approccio percettivo sembri avere maggiore validità predittiva riguardo alla sicurezza e come il clima di sicurezza risulti essere un significativo predittore della performance di sicurezza e specialmente della *safety partecipation,* ovvero dei comportamenti volontari che il lavoratore agisce per migliorare la sicurezza nella propria organizzazione (Clarke, 2006b).

Sempre nel tentativo di rispondere alla necessità di un quadro teorico maggiormente approfondito, nello stesso periodo, risultano particolarmente rilevanti gli studi di Zohar (e.g. Zohar, 2000, 2002, 2003; Zohar & Luria, 2005), di Melià (e.g. Melià, Sesé, Tomas & Oliver, 1992; Melià, 1998, 2002; Melià & Becerril, 2006; Melià & Sesè, 2007; Melià et al., 2008) e di Neal & Griffin (Griffin & Neal, 2000; Neal & Griffin 1997, 2000, 2002, 2004, 2006; Neal, Griffin & Hart, 2000).

Tra i molteplici contributi che Zohar ha offerto riguardo al clima di sicurezza, ricordiamo il suo sforzo nel fare chiarezza riguardo alla definizione del clima di sicurezza e dei criteri per discriminare le variabili che a tale costrutto afferiscono; l'approfondimento sulla natura multilivello del costrutto attraverso l'identificazione di due livelli di analisi (organizzativo e di gruppo); lo studio dei ruoli del top management e del preposto come determinanti nel processo di definizione e trasformazione del clima e delle variabili che moderano la relazione tra clima e performance di sicurezza, tra le quali ad esempio la forza del clima e il grado di routinizzazione/formalizzazione delle procedure.

Melià e collaboratori, a partire dagli anni novanta (e.g. Melià et al., 1992; Melià, 1998), studiano il clima di sicurezza con un approccio multilivello centrato sulla identificazione dell'agente responsabile di ogni attività inerente al clima di sicurezza (e.g. per ogni azione, omissione o responsabilità). Quattro principali agenti sono stati identificati come i soggetti che agiscono o che sono responsabili di aspetti relativi al clima: l'azienda, ovvero la direzione aziendale, i preposti, i colleghi di lavoro e il lavoratore. In riferimento a ciascun agente viene identificata una variabile di clima. Tale approccio risulta molto interessante anche perché permette di distinguere tra le variabili che riguardano il gruppo di lavoro (preposti e colleghi); in particolare, le ricerche di Melià e collaboratori mostrano come la variabile di clima relativa ai colleghi, accanto a quella relativa ai preposti, abbia un ruolo di mediazione tra il clima organizzativo e i comportamenti di sicurezza dei lavoratori.

Riguardo ai lavori di Neal e Griffin, di particolare interesse risulta la formalizzazione del clima di sicurezza come un fattore di secondo ordine a cui afferiscono più specifici fattori di primo ordine (comunicazione sulla sicurezza, formazione alla sicurezza, sistemi di sicurezza, valore dato alla sicurezza da parte del management). Tale struttura permette di studiare il clima sia nella sua globalità, sia come realtà complessa in cui è possibile verificare su quali dimensioni può essere maggiormente interessante ed efficace intervenire per avviare una processo di cambiamento. Inoltre, di riferimento per molti studi successivi è stata la loro modellizzazione dei legami tra clima di sicurezza, determinanti di performance di sicurezza (s*afety motivation*, ovvero motivazione alla sicurezza e *safety knowledge*, ovvero conoscenza riguardo alla sicurezza) e performance di sicurezza. Tale modello è stato successivamente ripreso in più studi meta-analitici, come quelli di Clarke (2006), di Nahrgang, Morgeson & Hofmann (2007) e di Christian et al. (2009), i quali rafforzano l'evidenza empirica di come il clima di sicurezza sia un forte predittore della performance di sicurezza. Ad esempio, Nahrgang et al., (2007) trovano una relazione negativa abbastanza forte ($r = -.23$) tra clima di sicurezza organizzativo e outcome di sicurezza (incidenti e infortuni) e una relazione positiva forte tra clima organizzativo e comportamenti di sicurezza (r = .42). Questi risultati vengono confermati da Christian et al. (2009), attraverso una path analysis meta-analitica. Essi infatti individuano un modello di mediazione totale in cui le determinanti della performance di sicurezza (*safety knowledge* e *safety motivation*) mediano completamente la relazione tra clima di sicurezza e performance di sicurezza. Inoltre dalla loro ricerca emerge come il modello testato si riveli un buon predittore di incidenti ed infortuni (il coefficiente che identifica la relazione tra comportamenti di sicurezza e outcome di sicurezza è -.31).

Zohar (2010b), facendo un bilancio della ricerca sul clima di sicurezza negli ultimi trent'anni, sottolinea l'importanza di questi risultati, evidenziando come essi dimostrino la stabilità e la forza della relazione tra clima di sicurezza e outcome di sicurezza, non solo tra diversi tipi di settori industriali ma anche tra diversi paesi. Tuttavia egli ribadisce anche come, a partire da questi risultati, sia importante affrontare alcune questioni ancora aperte che riguardano la ricerca sul clima di sicurezza, per dare migliori fondamenti teorici agli studi su questo tema. Tra queste, egli individua ad esempio la necessità di una più approfondita riflessione sulla definizione di clima di sicurezza, sui livelli di analisi e sullo sviluppo di sub-scale tarate sui diversi livelli di analisi, che tengano anche conto delle specificità dei diversi settori industriali. Inoltre, dato che negli ultimi anni ci si è soffermati sulla verifica della capacità predittiva del costrutto, egli sottolinea l'importanza di concentrare l'attenzione sulla verifica delle relazioni tra il clima di sicurezza e possibili antecedenti, mediatori, moderatori, considerando però anche altre variabili organizzative.

La definizione di clima di sicurezza

Una delle questioni maggiormente discusse, soprattutto negli anni novanta ma anche successivamente, riguarda la distinzione/sovrapposizione tra cultura e clima organizzativo e, di conseguenza, tra cultura e clima di sicurezza (e.g. Guldenmund, 2000). Molti autori si cimentano nella definizione di questi due costrutti. Ad esempio Flin et al. (2000) definiscono il clima come una istantanea sullo stato organizzativo, che offre un indicatore riguardo alla sottostante cultura del gruppo, dello stabilimento o della organizzazione. Analogamente, Zohar & Hoffman (2010) propongono un modello in cui il clima organizzativo può essere interpretato come un indicatore bottom-up – poiché si sviluppa a partire dalle percezioni dei lavoratori – dei valori cardine che formano la cultura organizzativa.

Date queste definizioni, è possibile procedere distinguendo il clima organizzativo dal clima di sicurezza. Il primo può essere definito come un insieme di percezioni riguardanti la globalità dell'organizzazione, il secondo invece va inteso come l'insieme delle percezioni legate ad un dominio specifico: la sicurezza. Il clima di sicurezza così definito si colloca entro ad un approccio al clima organizzativo che lo specifica in ambiti diversi, come ad esempio appunto quello della sicurezza, ma anche dell'innovazione e del servizio al cliente; in questa prospettiva si parla quindi di "clima di sicurezza", "clima per l'innovazione" e "clima relativo al servizio al cliente" (e.g. Schneider & Reichers, 1983). Un approccio di questo tipo permette di definire meglio i confini semantici del costrutto in oggetto e, dal punto di vista metodologico, di studiare legami tra predittore e outcome che sono operazionalizzati allo stesso livello di specificità, come ad esempio il legame tra clima di sicurezza e comportamenti di sicurezza.

Nel definire il clima di sicurezza, Zohar individua tre elementi fondamentali che aiutano a discriminare questo costrutto da altri costrutti organizzativi basati sulle percezioni dei lavoratori: le priorità relative tra obiettivi strategici (e.g. sicurezza) e necessità gestionali (e.g. rispetto della programmazione produttiva, efficienza produttiva); la coerenza tra dichiarazioni di intenti e azioni successive; la coerenza interna tra politiche, procedure e pratiche (e.g. Zohar & Luria, 2005; Zohar, 2010a, 2010b; Zohar & Hoffman, 2010).

Riguardo al primo elemento, esso si riferisce al fatto che spesso in contesti produttivi la sicurezza si trova contrapposta alla velocità e all'efficienza produttiva; conseguentemente, politiche e procedure riguardanti la sicurezza possono essere definite in termini di priorità relative tra sicurezza e obiettivi produttivi. Poiché queste priorità relative offrono ai lavoratori un modo facile per interpretare il significato reale delle politiche aziendali, è importante che le percezioni del clima di sicurezza siano riferite a queste priorità relative, che fanno emergere la reale importanza data alla sicurezza in azienda.

Il secondo elemento riguarda la coerenza percepita tra le dichiarazioni e il comportamento effettivo del management, e più in generale di chiunque ricopra un ruolo di responsabilità all'interno dell'organizzazione. Il grado di convergenza tra dichiarazioni e azioni offre, come nel caso del primo elemento, un segnale importante che permette ai lavoratori di raccogliere informazioni utili per capire quali sono i comportamenti che l'azienda realmente si attende dai propri dipendenti. Nel tempo, osservando l'ampiezza della distanza tra dichiarazioni e comportamenti del management, diventa sempre più chiaro il reale orientamento riguardo alla sicurezza, e di conseguenza anche il clima percepito diventa sempre più forte.

Il terzo elemento riguarda la potenziale distanza, in una organizzazione, tra politiche, procedure e pratiche. Dal momento che le politiche e le procedure sono prevalentemente definite dal management, mentre le pratiche vengono agite dai preposti, una prima potenziale causa di incoerenza risiede nella discrezionalità dei preposti nel tradurre in pratiche organizzative le politiche definite dal management. Quando è presente una discrepanza, ad esempio, tra politiche e pratiche, si verifica una situazione in cui i lavoratori ricevono messaggi contrastanti dal management e dai preposti. Un caso di messaggio contrastante potrebbe riguardare, ad esempio, il fatto che essi percepiscano una rilevante importanza data alla sicurezza da parte del management, e contemporaneamente una una minore importanza data alla sicurezza da parte del preposto, che potrebbe invece dare priorità agli obiettivi produttivi, ritenendo che sia questo il modo di rispondere al comportamento atteso dai suoi superiori.

Casi del genere mettono in evidenza l'importanza di studiare il clima in una prospettiva multilivello, in modo che possa essere possibile distinguere tra le percezioni del clima di sicurezza dei lavoratori relative al management (clima di sicurezza organizzativo) e le percezioni di clima relative al preposto (clima di sicurezza relativo al gruppo di lavoro), dal momento che queste possono essere tra loro simili e coerenti, ma anche divergenti.

Un costrutto multilivello

Il clima di sicurezza è un costrutto multilivello che può essere declinato principalmente a tre livelli: individuale, di gruppo e organizzativo. Quando è riferito a livello individuale, il clima viene valutato attraverso le percezioni di clima dei singoli individui (Barling, Loughlin & Kelloway, 2002), mentre quando è riferito a livello di gruppo o organizzativo esso viene concepito come la condivisione delle percezioni dei lavoratori che fanno parte dello stesso gruppo di lavoro o della stessa organizzazione, pur sempre rilevate attraverso le percezioni dei singoli individui (Zohar, 2002). In letteratura il clima organizzativo e il clima di gruppo sono stati largamente studiati separatamente. Tuttavia molti ricercatori sottolineano come i processi organizzativi si sviluppino simultaneamente a più livelli e quindi come un processo ad un certo livello possa influenzare l'andamento dello stesso o di un altro processo ad un diverso livello (e.g. Kozlowski & Klein, 2000; Shannon & Norman, 2008). Riguardo specificatamente al clima di sicurezza, questo implica che il clima assume diversi significati a diversi livelli organizzativi e nelle relazioni cross-level.

Tuttavia Zohar (2010b) precisa che l'analisi multilivello assume un qualche significato se si verificano almeno due condizioni. Una prima condizione, già illustrata nel precedente paragrafo, è la discrepanza tra le politiche e le procedure formalizzate dal management e le pratiche con cui tali politiche e procedure vengono implementate dai preposti. La seconda riguarda la capacità dei lavoratori di distinguere tra ciò che attiene al management e ciò che attiene ai preposti; nello specifico, tra le procedure definite dal management e la "traduzione" di tali procedure nelle pratiche ad opera dei preposti, e tra i comportamenti dei preposti voluti dal management e quelli che i preposti agiscono di propria iniziativa. Se si verificano queste condizioni diventa importante, e addirittura necessario, analizzare il clima di sicurezza rispetto i diversi livelli organizzativi (individuale, di gruppo e organizzativo).

Quando il clima percepito viene concettualizzato a livello individuale, si parla di "clima psicologico". Questo nasce da percezioni individuali relative ad un insieme coerente di politiche, di procedure e di pratiche, diversamente dal clima organizzativo che esprime piuttosto le percezione collettive e condivise di tali politiche, procedure e pratiche. James, Hater, Gent e Bruni (1978) descrivono il "clima psicologico" come "*the individual's cognitive representations of relatively proximal situational conditions, expressed in terms that reflect psychologically meaningful interpretations of the situation*"[3] (p. 786). Così, il clima psicologico di sicurezza riflette le percezioni individuali relative alle politiche, alle procedure e alle pratiche in materia di sicurezza.

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[3]"Le rappresentazioni cognitive dell'individuo di condizioni situazionali relativamente prossimali, espresse in modo da riflettere interpretazioni della situazione significative dal punto di vista psicologico"

Il clima psicologico di sicurezza non va quindi confuso con il clima organizzativo, o con quello di gruppo, che presuppongono una condivisione di percezioni relativamente del contesto lavorativo in relazione a questioni legate alla sicurezza. Queste percezioni condivise possono riguardare appunto l'organizzazione o il gruppo (Neal & Griffin, 2004; Zohar & Luria, 2005; Zohar & Hoffman, 2010). Secondo Zohar & Luria (2005), la condivisione delle percezioni, e quindi la creazione del clima, si collocano entro il quadro concettuale dell'interazionismo simbolico (Blumer, 1969; Schneider & Reichers, 1983) e del *sense-making* collettivo (Weick, 1995), dal momento che i membri di un'unità organizzativa interagiscono per creare una comprensione condivisa dei segnali che percepiscono.

Il ricercatore può operazionalizzare il clima di sicurezza a livello organizzativo o di gruppo aggregando le percezioni del clima psicologico se sono presenti specifiche condizioni quali l'omogeneità delle percezioni del clima all'interno del gruppo e la presenza di una sufficiente variabilità di clima tra i diversi gruppi. È ovviamente anche importante che l'insieme di lavoratori siano effettivamente un gruppo, per poter sensatamente considerare appunto il gruppo come unità di analisi.

In base al grado di omogeneità del clima di gruppo, è possibile distinguere tale clima in base alla forza, per cui là dove il grado di omogeneità all'interno dell'unità di analisi è alto si avrà un clima forte e, viceversa, dove vi sarà elevata eterogeneità la forza del clima sarà bassa.

Il clima, quindi, può essere analizzato sia rispetto al livello (alto – basso) sia rispetto alla forza (debole – forte). Alcuni studi (e.g. Zohar & Luria, 2004, 2005; Luria, 2008) hanno messo in rilievo come la forza del clima possa avere un importante ruolo di moderazione nelle relazioni tra clima e altri costrutti, come ad esempio i comportamenti di sicurezza, o lo stesso clima ad un altro livello (cfr. figura 1.2).

Considerando l'effetto che il clima a livello organizzativo può avere sul clima a livello

Figura 1.2. Esempio di un effetto di moderazione della forza del clima

di gruppo, una variabile che ha mostrato un importante effetto di moderazione è il grado di routinizzazione/formalizzazione del lavoro (e.g. Zohar & Luria, 2004, 2005; Zohar, 2008). Infatti secondo il modello di routinizzazione/formalizzazione (Hage & Aiken, 1969; Perrow, 1979) maggiore è il livello di routinizzazione del lavoro, maggiore sarà il livello di formalizzazione e di conseguenza minore sarà la discrezionalità dei preposti. Ad esempio, in presenza di una elevata routinizzazione/formalizzazione del lavoro, la relazione tra clima organizzativo e clima di gruppo risulterà più forte rispetto alle situazioni in cui il grado di routinizzazione/formalizzazione è minore.

Gli agenti di clima: management, preposti, colleghi di lavoro

Negli anni novanta si sviluppa un filone di ricerca sul clima di sicurezza che studia questo costrutto a partire da un approccio multilivello basato sugli agenti che sono responsabili, nell'organizzazione, delle diverse attività riguardanti la sicurezza (e.g. Melia et al.,1992; Melià, 1998). Anche Zohar e i suoi colleghi (e.g. Zohar, 2000, Zohar & Luria, 2005), che studiano il clima di sicurezza con un approccio multilivello, misurano il clima di sicurezza a livello organizzativo e di gruppo utilizzando due scale, che si riferiscono a due specifiche figure aziendali, rispettivamente la direzione aziendale e il preposto. Concretamente, gli indicatori relativi al clima organizzativo riguardano scelte compiute dalla direzione aziendale in relazione, ad esempio, al volume e alla qualità degli investimenti in macchinari e tecnologie per il miglioramento dei livelli di sicurezza aziendali e in percorsi di formazione sulla sicurezza, ma anche scelte in relazione alla definizione di nuove strategie e procedure per migliorare la performance di sicurezza.

Molte sono le scale che sono state sviluppate in letteratura sul clima di sicurezza a livello organizzativo (cfr. Guldenmund, 2000; Flin et al. 2000; Seo, Torabi, Blair e Ellis, 2004); Glendon, 2008) e molti sono i lavori che studiano il clima di sicurezza considerando solamente il livello organizzativo.

Osservando gli studi pubblicati in lingua inglese dal 2006 al 2010 che utilizzano scale relative al clima di sicurezza, è interessante notare che su 90 lavori ben il 72% delle ricerche analizzano il clima solo a livello organizzativo, e, nel complesso, l'82% fa uso di scale di clima centrate sul livello organizzativo, accanto ad altre misure di clima. Se poi si va a vedere in quali settori vengono maggiormente utilizzate scale che riguardano solo il livello organizzativo, emerge che questi sono l'industria (30%), la sanità (30%) e i trasporti (11%). Il 20% dei lavori riguardano la validazione di una nuova scala, mentre l'80% utilizza scale proposte in studi precedenti.

Le ricerche che analizzano il clima oltre che a livello organizzativo anche a livello di gruppo sono il 24 %, mentre lo studio esclusivo del clima a livello di gruppo riguarda solo un 17% di ricerche. Trasversalmente rispetto agli ambiti applicativi, più del 50% di queste ricerche utilizza o fa riferimento a scale definite da Zohar e colleghi, evidenziando come il lavoro di questi autori risulti un rifermento importante per l'analisi del clima di sicurezza a livello di gruppo (e.g. Zohar, 2000; Zohar & Luria, 2004, 2005; Zohar, 2008, 2010a, 2010b).

Essi, come accennato precedentemente, dimostrano la necessità di analizzare distintamente il clima su più livelli e in particolare come il clima di gruppo abbia un ruolo di mediazione tra il clima organizzativo e la performance di sicurezza. (Cfr. figura 1.3)

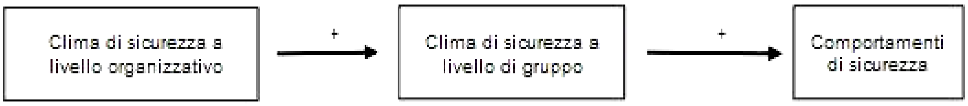

Figura 1.3. Il modello di Zohar e Luria (Zohar & Luria, 2005)

Tuttavia fino agli inizi del nuovo millennio nello studio del clima di sicurezza l'attenzione agli agenti di clima non sembra un focus di particolare interesse. Melià e Becerril (2006), facendo una rassegna dei lavori sul clima di sicurezza, provano a sistematizzare le dimensioni di clima secondo questo tipo di approccio e individuano quattro agenti di clima responsabili di ciascuna attività inerente la sicurezza nell'organizzazione: la direzione aziendale, i preposti, i colleghi di lavoro e i lavoratori. Mentre i ruoli della direzione aziendale e dei preposti risultano ampiamente studiati in letteratura e questi vengono identificati come protagonisti di specifici climi di sicurezza, rispettivamente clima di sicurezza organizzativo e di gruppo (e.g. Zohar 2000, 2008; Zohar & Luria, 2005; Johnson, 2007; Allen, Baran & Scott, 2010), altrettanto non si può dire del ruolo dei colleghi di lavoro che nella maggior parte degli studi, quando è presente, viene considerato come una dimensione di clima.

Il clima di sicurezza relativo ai colleghi di lavoro

Turner e Parker (2004) evidenziano come la ricerca sul ruolo del gruppo in relazione con la sicurezza nei luoghi di lavoro non sia stata molto approfondita. Tuttavia, a partire dagli anni novanta, molti studi hanno mostrato come per migliorare la sicurezza intervenire sul gruppo invece che solo sul singolo possa essere maggiormente efficace (e.g. DeJoy, 1996;

Hofmann, Jacobs & Landy, 1995).

A tale proposito Tesluck e Quigley (2003), riprendendo gli studi in psicologia delle organizzazioni sul ruolo del gruppo di lavoro, fanno un elenco dei motivi per cui vale la pena prendere in considerazione tale soggetto. In particolare sottolineano come il lavoratore si senta maggiormente membro del gruppo di lavoro più che dell'organizzazione nel suo complesso, e quindi come il gruppo abbia un ruolo importante nell'influenzare atteggiamenti e comportamenti dei singoli lavoratori, ma anche nel supportare il loro benessere. Riguardo alla salute e alla sicurezza nel luogo di lavoro di conseguenza il gruppo può avere quindi un ruolo strategico nell'aiutare ad evitare incidenti e infortuni, ad esempio promuovendo un clima che aiuti ad aumentare l'attenzione alla sicurezza.

Il ruolo dei colleghi di lavoro in relazione al clima di sicurezza è stato studiato in passato prevalentemente come una dimensione del clima di sicurezza organizzativo, facendo riferimento ad una pluralità di aspetti tra cui: il supporto dei colleghi (e.g. Seo et al. 2004; Burt, Sepie & McFadden, 2008); le norme sociali (e.g. Hahn et al. 2008, Fugas, Silva & Melià, 2009; Kath, Marks & Ranney, 2010); le pratiche dei colleghi (e.g. Singer et al., 2007; Melià, 1998; Melià & Becerril, 2006; Melià et al, 2008; Jiang et al., 2009), le interazioni tra colleghi (e.g. Cavazza et al., 2009; Zohar & Tenne-Gazit, 2008; Zohar, 2010); e un più generale insieme riferito alla sicurezza dei colleghi (e.g. Gyekyes et al., 2009; Morrow et al., 2010). Pochissimi sono gli studi che esplorano il ruolo dei colleghi di lavoro come uno specifico agente a cui afferisce uno specifico clima di sicurezza (e.g. Melià & Becerril, 2006; Melià et al., 2008). Tra questi, Melià et al. (2008) identificano i colleghi di lavoro come un importante agente di sicurezza collettivo, al pari della direzione aziendale e del preposto. Infatti anche il clima relativo ai colleghi, nella sua peculiarità si rivela un buon predittore dei comportamenti di sicurezza dei lavoratori. Inoltre risulta a sua volta predetto dal clima organizzativo e dal clima relativo al preposto, suggerendo una interessante ipotesi che vedrebbe il clima dei relativo ai colleghi come mediatore tra il clima organizzativo e il clima riferito al preposto da un lato e la performance di sicurezza del lavoratore dall'altro.

Un interessante lavoro, che studia in modo approfondito il ruolo dei colleghi di lavoro all'interno del gruppo di lavoro e in relazione alle prestazioni dei lavoratori, è quello di Chiaburu e Harrison (2008). Questi autori, facendo riferimento ai principi della teoria della interdipendenza di Kelley e Thibaut (1978), attraverso una meta-analisi su 161 campioni per un totale di circa 78.000 lavoratori, offrono una cornice teorica sui legami tra comportamenti dei colleghi di lavoro e outcome dei lavoratori. In particolare essi rilevano che i comportamenti dei colleghi hanno un effetto diretto sulla performance e che questo effetto è distinto dall'influenza del preposto.

Da questi risultati sembra quindi lecito poter considerare il clima di sicurezza come un costrutto multilivello che si configura distintamente a più livelli, organizzativo e di gruppo, e che inoltre a livello di gruppo può essere a sua volta distinto in clima di sicurezza relativo al preposto e clima di sicurezza relativo ai colleghi di lavoro.

La struttura fattoriale del clima di sicurezza

Una delle questioni di rilievo ancora aperte rispetto allo studio del clima di sicurezza riguarda la sua struttura fattoriale. Infatti dallo studio della letteratura non emerge un chiaro accordo sulla struttura del clima, soprattutto in relazione alle dimensioni che lo caratterizzano. Più lavori hanno provato ad identificare le dimensioni più ricorrenti. Ad esempio Flin et al. (2000), in un lavoro di comparazione degli strumenti utilizzati in ricerche riguardanti il clima di sicurezza svolte in ambito industriale, individuano tra i temi maggiormente ricorrenti gli atteggiamenti e comportamenti del management e dei preposti (72% degli studi), i sistemi di sicurezza (67%) e il rischio (67%). Nel lavoro di Seo et al. (2004) che analizza la dimensionalità delle scale di misura del clima di sicurezza a partire dallo studio di Zohar (1980) fino al più recente studio di Mearns, Whitaker e Flin (2003) vengono rilevati studi che identificano da un minimo di 2 dimensioni (Dedobbeleer & Beland, 1991) ad un massimo di 11 dimensioni (Mearns et al., 2003) del clima di sicurezza, evidenziando come l'individuazione delle dimensioni che caratterizzano il clima di sicurezza da studio a studio risponda a criteri molto vari.

La difficoltà nell'identificazione di una dimensionalità condivisa del clima di sicurezza viene confermata anche dall'instabilità delle strutture fattoriali identificate se replicate su campioni diversi o sullo stesso campione in studi longitudinali. A tale proposito alcuni autori, come Cooper e Philips (2004), arrivano ad affermare che la struttura fattoriale è unica per ogni specifica popolazione e quindi che non sia possibile prevedere una specifica struttura fattoriale a priori.

Al di là di questo punto di vista estremo, che tuttavia sottolinea la difficoltà dei ricercatori rispetto a tale questione, da una attenta analisi della letteratura due sembrano gli orientamenti prevalenti. Una parte di studiosi ritiene che il clima di sicurezza sia un costrutto multi-dimensionale (e.g. Mearns et al. 2003; Cooper e Philips, 2004; Zohar & Luria, 2005; Zohar, 2000) e un'altra parte di studiosi ritiene il clima un costrutto latente uni-dimensionale composto da più fattori di primo ordine (e.g. Neal et al., 2000; Griffin & Neal, 2000).

Lo studio meta-analitico di Christian et al. (2009) dimostra il successo di quest'ultimo punto di vista, e molti altri studiosi (e.g. Zacharotos, Barling & Iverson, 2005; Probst, Estrada, 2010; Zohar, 2008; Dal Corso, 2008; Sinclair, Martin & Sears, 2010) fanno riferimento alla proposta di struttura fattoriale di Neal e Griffin (Griffin & Neal, 2000; Neal & Griffin, 2004) per studiare il clima di sicurezza. Nella struttura proposta da questi autori, i fattori di primo ordine riflettono le percezioni dei lavoratori riguardo alle specifiche politiche, procedure e pratiche portate avanti in azienda in relazione alla sicurezza, mentre il fattore di secondo ordine riflette come i lavoratori credono che la sicurezza sia considerata da parte dell'organizzazione in cui lavorano. Griffin e Neal (2000) identificano quattro fattori di primo ordine: i valori del management, che si riferiscono a quanta importanza realmente dà la direzione aziendale alla sicurezza; i sistemi di sicurezza, tesi a verificare le percezioni sull'efficacia della struttura sicurezza in azienda; la formazione alla sicurezza, che si riferisce alla qualità e quantità della formazione realizzata in azienda; la comunicazione sulla sicurezza, che riguarda i modi con cui le questioni relative alla sicurezza vengono comunicate.

Come in altri ambiti di ricerca che riguardano le organizzazioni, di volta in volta va considerato se può essere più interessante per una valutazione fare riferimento agli specifici fattori di primo ordine o al più generale fattore di secondo ordine (Hogan & Roberts, 1996). Infatti, per analizzare ad esempio specifiche pratiche organizzative sulla performance di sicurezza può essere più utile riferirsi a specifici fattori di primo ordine, mentre se si vuole ad esempio studiare la relazione tra clima di sicurezza nel suo complesso e insicurezza lavorativa è sicuramente più utile riferirsi al fattore di secondo ordine che del clima di sicurezza offre una misura sintetica.

La performance di sicurezza

Molti studi (e.g. Zohar, 2000; Zohar & Luria, 2005; Neal & Griffin, 2006; Probst, Brubaker & Barsotti, 2008; Cavazza & Serpe, 2009; Christian et al., 2009; Melià et al., 2008) identificano il clima di sicurezza come *leading indicator* della performance di sicurezza dei lavoratori, offrendo evidenza empirica di una forte e positiva relazione tra le due variabili. Tuttavia non molti studi (e.g. Neal et al. 2000; Griffin & Neal, 2000; Dal Corso, 2008; Newnam, Griffin & Mason, 2008) hanno approfondito questa relazione considerando anche le variabili che determinano la performance di sicurezza, quali ad esempio la motivazione e la conoscenza. La meta-analisi di Christian et al. (2009) approfondisce le relazioni tra antecedenti, determinanti, performance e outcome di sicurezza, facendo riferimento al modello proposto da Neal e Griffin (Neal e Griffin, 2000; Griffin & Neal, 2000), ispirati a loro volta dagli studi sviluppatisi negli anni novanta sulla performance (Campbell et al.,1993; Borman & Motowidlo,1993).

Campbell et al. (1993) propongono un modello che specifica ciò di cui la performance si compone (le cosiddette "componenti"), e ciò che la determina (le cosiddette "determinanti"). Per quanto concerne le diverse componenti della performance, queste non vengono definite esplicitamente dagli autori, in quanto specifiche per ogni tipo di lavoro, ma vengono genericamente indicate con PC_i (i = 1, … , k, dove k è il numero delle componenti). Innanzitutto Campbell e collaboratori si preoccupano di definire la performance, affermando che essa può essere intesa come un sinonimo di comportamento, ovvero qualcosa che la persona fa e che può essere osservato. In particolare essi definiscono la performance come "*those actions or behaviours that are relevant to the organization's goals and that can be* *scaled (measured) in terms of each individual's proficiency*"[4] (p. 40). Successivamente, la definizione di job performance è stata rielaborata da vari autori, tra cui ad esempio Parker e Turner (2002), i quali la definiscono come "*behaviors enacted by an employee that are aimed at meeting organizational goals*"[5] (p. 70); come si vede, fondamentalmente tale definizione non si discosta di molto da quella data da Campbell e colleghi. Una volta definita la performance, questi ultimi descrivono il loro modello, in cui la performance dipende dalle determinanti (che sostanzialmente sono conoscenze dichiarative e conoscenze procedurali, nonché abilità e motivazione) che a loro volta dipendono da specifici predittori quali, ad esempio, i tratti di personalità, il livello di istruzione, l'esperienza.

Le determinanti della performance

Nel modello di Campbell e collaboratori (Campbell et al., 1993) le differenze individuali relative a ciascuna componente di performance sono funzione delle determinanti, ovvero motivazione, abilità e conoscenze. Queste ultime comprendono da un lato le conoscenze dichiarative, dall'altro quelle procedurali. Le conoscenze dichiarative sono quelle relative a fatti e cose; in particolare esse rappresentano una comprensione di ciò che è richiesto per eseguire il compito dato. Poiché le componenti che riguardano le conoscenze procedurali e le abilità si riferiscono alla combinazione tra conoscenze dichiarative e sapere fare, queste sono conseguenti alla determinante riguardante le conoscenze dichiarative. La motivazione viene definita come l'effetto combinato di tre scelte di comportamento ovvero della scelta di

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[4] "quelle azioni e quei comportamenti che risultano rilevanti per il raggiungimento degli obiettivi aziendali e che possono essere misurati in termini di livello di contributo offerto dal singolo lavoratore"

[5] "comportamenti messi in atto dal lavoratore mirati al raggiungimento degli obiettivi organizzativi"

impiegare la propria energia in qualcosa, della scelta del livello di energia da impiegare ed infine della scelta di continuare ad impiegare quel livello di energia nel tempo.

Neal e collaboratori (e.g. Neal et al. 2000; Griffin & Neal, 2000) rielaborano le determinanti individuate dal gruppo di ricerca di Campbell adattandole alla performance di sicurezza. Le determinanti relative alla conoscenza vengono associate in una variabile globale che essi definiscono *safety knowledge*; inoltre gli autori, tralasciando le abilità, definiscono la motivazione in modo più dettagliato, distinguendo la motivazione alla *compliance* dalla motivazione alla *participation*. Per *safety knowledge* gli autori intendono le conoscenze che i lavoratori hanno rispetto alle procedure e alle pratiche riguardanti la sicurezza. La motivazione alla *compliance* viene vista come la motivazione a svolgere la propria mansione e quindi a fare ciò che è dovuto, mentre la motivazione alla *participation* è la motivazione a partecipare volontariamente in attività che promuovono la sicurezza all'interno della propria organizzazione e quindi a fare qualcosa in più del dovuto. Nel loro modello in cui mettono in relazione il clima di sicurezza e la performance di sicurezza, essi verificano che le determinanti della performance mediano completamente tale relazione (figura 1.4).

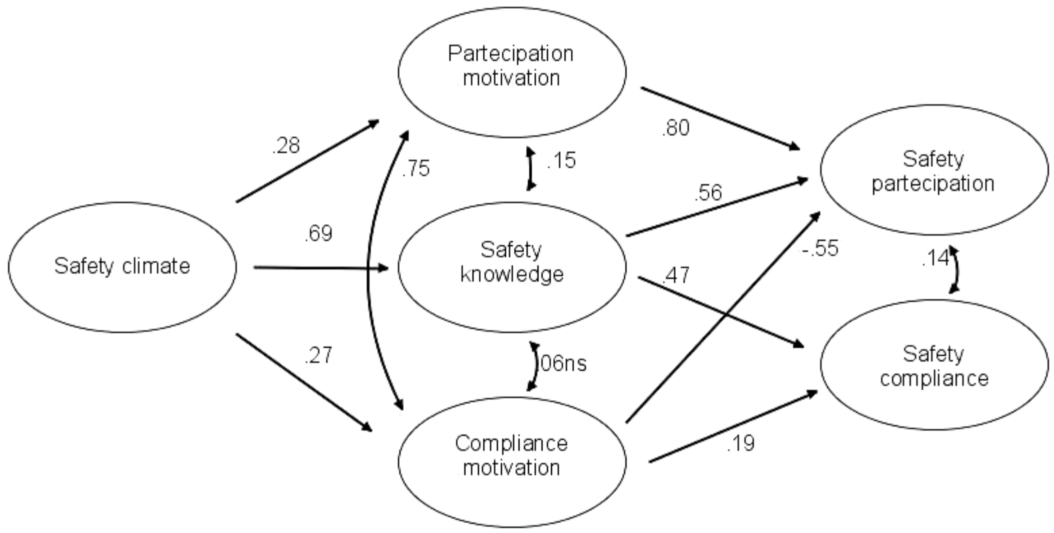

Figura 1.4. Il modello di Griffin e Neal (2000) sulla relazione tra clima di sicurezza e performance di sicurezza

Le componenti della performance

Mentre Campbell e colleghi non specificano le componenti della performance, Borman e Motowidlo (1993) ipotizzano che tali componenti possano essere raggruppate in due categorie: la *task performance* e la *contextual performance*. Neal e Griffin nel loro modello riprendono questa categorizzazione riferendola alla performance di sicurezza e traducendo le due categorie di componenti identificate da Borman e Motowidlo in *safety compliance* e *safety participation*. Per *safety compliance* essi intendono tutti i comportamenti che riguardano l'adesione e il rispetto delle procedure, e più in generale il lavorare in modo sicuro (e.g. usare in modo appropriato i dispositivi di protezione individuale, seguire la segnaletica negli spostamenti all'interno dello stabilimento). La *safety participation* riguarda il promuovere volontariamente la sicurezza nel proprio luogo di lavoro, aiutando ad esempio i colleghi o promuovendo i programmi per il miglioramento della sicurezza all'interno della propria organizzazione.

La distinzione tra comportamenti di adesione alle procedure di sicurezza (*safety compliance*) e comportamenti partecipativi nell'ambito della sicurezza (*safety participation*) viene supportata dai risultati della ricerca di Neal e Griffin, e risulta molto utile per studiare i processi che legano il clima di sicurezza a ciascuna di queste due singole componenti, e non solo alla performance di sicurezza in generale. Gli autori infatti trovano ad esempio che la motivazione alla *participation* è fortemente legata alla *safety participation.* Al contrario, la motivazione alla *compliance* risulta debolmente collegata alla *safety compliance* e addirittura negativamente collegata alla *safety participation*. Invece, le conoscenze relative alla sicurezza risultano fortemente collegate ad entrambe le componenti della performance.

Questi risultati vengono prevalentemente confermati anche nello studio meta-analitico di Christian e colleghi (2009). Inoltre in questo studio, condotto attraverso una path analysis che riprende, seppure semplificandolo, il modello di Neal e Griffin, essi trovano una relazione negativa statisticamente significativa tra performance di sicurezza e outcome di sicurezza, quali incidenti e infortuni. Tale dato viene confermato anche in analoghe ricerche (Nahrgang, Morgenson & Hofmann, 2007), evidenziando come il clima di sicurezza sia a livello organizzativo che a livello di gruppi risulti un buon predittore non solo dei comportamenti di sicurezza, ma attraverso quest'ultimi, anche degli outcome di sicurezza.

Il presente lavoro intende contribuire all'approfondimento degli studi riguardanti il clima di sicurezza con un approccio integrato. Tale approccio è teso a distinguere e quindi valorizzare il ruolo di tutti gli agenti di clima (direzione aziendale, preposti e colleghi di lavoro), sostenendo l'ipotesi che il clima di sicurezza possa essere pensato come un sistema di climi articolato su più livelli (organizzativo e di gruppo) in cui ciascun clima, a partire dalle proprie specificità, abbia una particolare influenza sulla performance di sicurezza.

Esso si articola in cinque capitoli di cui uno introduttivo, tre centrali in forma di articolo in lingua inglese che presentano tre studi realizzati durante il periodo di dottorato e un capitolo conclusivo.

In questo primo capitolo introduttivo è stata realizzata una presentazione dello stato dell'arte nella ricerca sul clima di sicurezza e alcuni aspetti specifici che lo caratterizzano, e sulla performance di sicurezza, a fondamento del lavoro che verrà presentato nei capitoli successivi.

Nel secondo capitolo viene presentato uno studio sullo sviluppo e la validazione di uno strumento elaborato per la misurazione del clima di sicurezza, mediante la tecnica dell'analisi fattoriale confermativa multilivello.

Nel terzo capitolo viene presentata una ricerca che si propone di esplorare la relazione tra il sistema di clima di sicurezza centrato sugli agenti di clima e i comportamenti di sicurezza, in particolare verificando il ruolo di mediazione svolto dal clima di sicurezza relativo ai colleghi di lavoro nei confronti delle relazioni tra clima di sicurezza organizzativo e performance di sicurezza, e tra clima di sicurezza relativo ai preposti e performance di sicurezza.

La ricerca presentata nel quarto capitolo mira alla verifica, sempre tramite tecniche di analisi multilivello, della capacità predittiva di un modello in cui le relazioni tra il sistema integrato di climi (organizzativo, relativo ai preposti e relativo ai colleghi di lavoro), performance di sicurezza e outcome di sicurezza vengono mediate dal ruolo delle determinanti dei comportamenti di sicurezza.

Il capitolo conclusivo offre una visione d'insieme dei risultati ottenuti nei diversi studi realizzati, evidenziandone anche limiti, punti di forza e possibili tracce per futuri ampliamenti della ricerca.

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Capitolo 2

Development and validation of an Integrated Organizational Safety Climate Questionnaire for the Italian industrial context with multilevel confirmatory factor analysis

Abstract

Meta-analytic and traditional reviews on safety climate reveal theoretical and methodological safety climate issues still open. The main aim of this study is to propose a questionnaire which combines different approaches to safety climate, trying to give a contribute about these issues. The present research led to the development of a new questionnaire to measure safety climate, suitable for blue-collar workers, and to the evaluation of its psychometric properties, and usefulness to measure safety climate in the industrial sector. Multilevel confirmatory factor analysis (MCFA) was used to properly evaluate the factor structure underlying the safety climate questionnaire composed of three scales: Organizational Safety Climate (OSC) scale, Supervisor's Safety Climate (SSC) scale and Co-workers' Safety Climate (CSC) scale. The clear distinction, made with the use of three different scales, among safety agents (organization, supervisor, co-workers), gives an instrument that can assess workers' perceptions focused on each level, and allows to deeply explore, for instance, lateral relationships of supervisor's safety climate and co-workers' safety climate, analysing the interactions between the roles of these two safety agents. A two-level design was used, considering the individual level and the work-group level. Data collection involved 1312 blue-collars from 7 Italian manufacturing companies. The MCFA results

demonstrated the importance to use proper analysis to study the factor structure of a multilevel construct as safety climate, and confirmed the theoretical structure of safety climate purposed from Griffin and colleagues, using not only psychological climate (that is, the individual level), but also the group level safety climate.

Introduction

Safety climate and culture research developed successfully since the inquiry into Chernobyl disaster identified inadequate safety culture as a major underlying factor for the accident (IAEA, 1986). However, the most important seminal paper on this topic was proposed by Zohar in 1980, some years before the disaster. In this paper Zohar offered a great contribution on the definition and operationalization of safety climate, showing how this construct is related to the general safety level in the organizations and, in particular, how "management commitment to safety is a major factor affecting the success of safety programs in industry" (1980, p. 101).

The ensuing success of this approach to safety is indicated by later studies, which show how safety climate is a robust predictor of safety subjective outcomes, such as safety behaviour, and of objective outcomes, such as accidents and injuries (Christian, Bradley, Wallace and Burke, 2009). From the nineties the literature about safety climate increased markedly, and a large number of scales have been created (Glendon, 2008). Nevertheless meta-analytic studies and safety climate reviews on safety climate reveal that some issues are still open from a theoretical and methodological point of view (Shannon & Norman, 2009; Zohar, 2010). From a theoretical point of view, for example there is still ambiguity about safety climate themes and dimensions (Zohar, 2010).

From a methodological point of view there is confusion about the levels of analysis, because many measuring instruments in safety climate research use items referring at the same time to organizational, group and individual levels. Zohar (2010, p. 1521) suggests that “given the target of climate perceptions can relate to organization or group levels of analysis (i.e. senior management commitments and policies vs. supervisory or co-worker practices), it follows that climate measurement should be based on level-adjusted subscales offering separate measures for climates associated with respective organizational levels. […] the practice of mixing items associated with divergent levels of analysis must be discontinued in order to avoid level discrepancy errors in safety climate measurement.”

Furthermore, authors sometimes analysing safety climate didn't considered its multilevel structure and the importance to test for example within-unit homogeneity of perceptions (e.g. adopting r_{wg} or AD criteria) or between-unit variability relating to relevant units of analysis. If the data collected are multilevel in nature they should be analysed accordingly. Shannon et al. (2009, p. 329), referring to factor analysis of safety climate surveys, argued: “It appears that most, if not all, determinations to date of the factor structure are incorrect, since they have treated the data from individual survey respondents as completely independent” and emphasised the importance that a proper analysis requires adjustment to incorporate the multilevel nature of the data. Muthén (1991) states that this involves decomposing the variances into between-group and within-group estimates.

The main aim of this study is to propose a questionnaire which combines different approaches to safety climate, trying to give a contribute about the theoretical and methodological safety climate issues still open. Particularly, the present study tries to combine specific facets of the work of Melià (e.g. Melià, 1998, 2002; Melià & Sesè, 2007; Melià, Mearns, Silva & Lima, 2008), Zohar (e.g. 1980, 2000, 2010; Zohar & Luria, 2005), and Griffin & Neal (Griffin & Neal, 2000; Neal & Griffin 2000, 2002, 2004; Neal, Griffin & Hart, 2000). These specific facets concern the selection of items related properly to safety climate, the identification of the agents involved in safety activities connected with safety climate, the identification of safety climate structure and specific dimensions, and the statistical analyses used with safety climate data.

Another aim is to focus the questionnaire on the industrial sector, giving special attention, in this specific context, to blue-collar workers. Finally the present study also intend to promote this kind of approach to safety in Italy, where the construct of safety climate has been considered in a limited number of studies (e.g. Cavazza & Serpe, 2009; Bisio, 2009; Dal Corso, 2008). Furthermore, at present no validate scales exist in the Italian language, focussing exclusively on the safety climate.

By safety climate literature and particularly by meta-analysis studies (Christian et al., 2009; Nahrgang, Morgeson & Hofmann, 2007, Beus, Payne, Bergman & Arthur, 2010) the importance of safety climate emerges because of its ability to predict safety behaviour, accidents and injuries. So safety climate has become a leading indicator of safety performance.

Safety climate is considered a subset of organizational climate with a specific domain, safety. The definitions of safety climate varied across the studies. Zohar (1980, p. 96) defines it as "a summary of molar perceptions that employees share about their work environments ... a frame of reference for guiding appropriate and adaptive task behaviors". Coyle, Sleeman & Adams (1995) define safety climate as the objective measurement of attitudes and perceptions toward occupational health and safety issues. Williamson, Feyer, Cairns and Biancotti (1997) speaks of safety climate as a summary concept describing the safety ethic in an organization or workplace which is reflected in employees' beliefs about safety.

This plurality of definitions may be explained by differences in approaching this issue in each study. Clarke (2006) was able to discern three distinct approaches in her review of the literature: (1) an attitudinal approach; (2) a perceptual approach; and (3) mixed models, combining attitudes and perceptions. The present study followed the perceptual approach, and referred to the most common and used definition of perceived safety climate which refers to the individual perceptions of individuals on policies, procedures and practices relating to safety in the workplace (Griffin & Neal, 2000).

In the following pages this paper try to give a contribution on specific issues still open about safety climate, combining some aspects from different studies of Melià, Zohar and Neal & Griffin. On table 1 a synthetic overview on safety climate studies by these scholars are presented. In detail, for each author, the levels of analysis, themes and dimensions of safety climate structure, the composition of safety climate scales and sub-scales, the type of the conducted data analyses and the identified factor structure are shown. The last column summarizes the main features about safety climate research of the present study. Furthermore, the last raw highlights some specific facets of the work of each author, selected for the present research. In the following paragraphs these specific facets are presented and analysed.

A multilevel construct

Climate can be conceptualized at both the individual level (e.g., Barling, Loughlin, & Kelloway, 2002) and the group or unit level (e.g., Zohar, 2000). Taken at the individual level, climate is assessed via individual level perceptions of climate (Barling et al., 2002), and taken at the group or organizational level, climate is the sharing of such perceptions commonly operationalized under a specific leader, supervisor, or group or organization (Zohar, 2002).

James, Hater, Gent and Bruni (1978) termed the individual level climate perception as *psychological climate* and defined it as “the individual’s cognitive representations of relatively proximal situational conditions, expressed in terms that reflects psychologically meaningful interpretations of the situation” (p. 786).

Under specific conditions researchers can operationalize organizational (or group) safety climate by aggregating psychological climate perceptions within the organizational (or group) level. Therefore organizational (or group) safety climate refers to the shared perceptions of work environment characteristics as they pertain to safety matters that affect a group of individuals (Neal & Griffin, 2004; Zohar & Luria, 2005). Zohar & Hoffman (2010) identify two processes which mainly promote the emergence of climate: symbolic interactionism (Blumer, 1969; Schneider & Reichers, 1983) and collective sense-making (Weick, 1995, 2005), that is, members of organizational units interact to create mutual understanding of extracted cues.

Since group members interact more often with each other than with workers of other groups, it is likely that shared perceptions about their unit or about their organization emerge among them.

The factorial structure of safety climate

Another important issue concerning safety climate scales is their factorial structure. In the present study safety climate is considered as having a hierarchical structure with psychological, group and organizational levels (e.g. James & James, 1989), in which a singular, higher order factor is comprised of more specific first order factors (Griffin & Neal, 2000).

In the literature there is not clear agreement about safety climate structure especially about the specific first order factors involved by the second order factor. The meta-analytic work of Christian et al. (2009) demonstrates the success of Neal and Griffin safety climate modelling work, and many other scholars (e.g. Zacharotos, Barling & Iverson, 2005; Probst, Estrada, 2010; and Zohar & Luria, 2005; Zohar, 2008; Dal Corso, 2008) refer to the Neal & Griffin factor analytic and path modelling research (Griffin & Neal, 2000; Neal & Griffin, 2004) to examine specific facets of safety climate.

Griffin & Neal (2000) affirmed that the first order factors of safety climate should reflect perceptions of safety related policies, procedures and practices, and the higher order factor should reflect the extent to which employees believe that safety is valued within the organization.

Griffin & Neal (2000) identified 4 first order factors: Management values, which concern the degree to which managers valued safety in the workplace; Safety inspections, which refer to the effectiveness of safety systems in the organization; Safety communication, which is about the way in which safety issues were communicated; Safety training which refers to the quality and quantity of the employees' opportunities to be trained. In later studies of Neal and Griffin the factor “Safety inspections” was generalized to “Safety systems”. The present study, as shown in table 1, adopted this safety climate structure.

As in other areas of organizational assessment, the purpose of the assessment should determine whether a specific first-order factors or a global higher-order factor is more appropriate (Hogan & Roberts, 1996). For some purposes, such as determining the overall impact of safety climate on safety outcomes, a higher order factor of safety climate will be most appropriate. For other purposes, such as determining the impact of distinct organizational practices on task performance, the use of specific first-order climate factors will provide more detailed diagnostic information. In the present work, a system of safety climate scales is developed, trying to satisfy both these purposes.

Safety agents

In the same way, it could be interesting to analyse each safety climate statement from the point of view of the agent that performs or is responsible for the safety activity. In the nineties, a structured multilevel view of safety climate was introduced, based on the identification of the agent responsible for each safety climate statement (e.g. Melià, 1998; Melià and Sesè, 2007, Melià et al., 2008).

Zohar (2000; Zohar & Luria, 2005) split safety climate into two scales: one for organizational level climate and one for group level climate. Organizational level climate indicators refer to issues such as financial expenditure on safety devices and personnel decisions based on safety criteria. Concerning organizational level indicators, the use of "competitive" items (e.g. safety vs. speed) is an important aspect to consider (Zohar, 2008). The main agent of organizational level climate is the top management. Group-level indicators, however, refer to issues such as supervisory monitoring and rewarding practices, individualized coaching of group members, and willingness to interrupt production to correct safety hazards. The main agent of group level climate is the supervisor of the group. Supervisor discretion depends on a number of issues such as the presence of competing operational demands, and the fact that procedures rarely cover all the situations. Workers, as members at the same time of units and of the entire organization, perceive signals both from top management regarding policies and from their group supervisor regarding how these policies are implemented in their department.

Recently Melià and Becerril (2006), in a review of the safety climate literature, organized safety climate dimensions into a comprehensive schema from the point of view of the “agents” of the safety climate actions or omissions. Four main agents, that is the subjects that perform or are responsible for each safety issue inside the company, have been identified: the company, i.e. the top management, supervisors, co-workers, and the worker who answers the safety climate questionnaire. Top management and supervisor role was deeply explored (e.g. Zohar, 2000, 2005; Clarke, 2006; Allen, Baran and Scott, 2010). At the moment the role of co-worker has been explored regarding different facets: co-workers' support (e.g. Chiaburu & Harrison, 2008; Burt, Sepie and McFadden, 2008); social norms (e.g. Hahn et al. 2008, Fugas, Silva & Melià, 2009; Kath, Marks & Ranney, 2010); co-workers' practices (e.g. Singer et al., 2007; Melià, 1998; Melià and Becerril, 2006; Melià et al, 2008; Jiang et al., 2009), co-workers' interaction (e.g. Cavazza et al., 2009; Zohar & Tenne-Gazit, 2008; Zohar, 2010); and also regarding a more generalized block as co-worker safety (e.g. Gyekyes et al., 2009; Morrow et al., 2010). Almost always these studies considered the set of items about co-workers as a dimension of a whole safety climate scale.

Following Zohar (2010), the present study tries to discern what set of items can be considered a dimension of a safety climate scale and what cannot. Using Melià safety climate researches (Melià, 1998, 2002; Melià & Sesè, 2007; Melià et al., 2006, 2007, 2008) as a point of departure, it will explore the alternative for the co-workers' safety climate scale. This scale has been thought with a second order factor, which reflects the extent to which employees believe that safety is valued within the co-workers, and four first order factors of safety climate, which reflect perceptions of safety related to co-workers' values, support, practices and interactions with peer about safety.

Statistical methods

Another issue related to safety climate concerns the statistical methods used in safety climate studies (Shannon & Norman, 2008; Zohar, 2010). The object of measurement is typically the work group or the company. Because the workers within each group are rating the same object, there is inherent correlation in their scores – the data are multi-level, and this must be considered in determining the factor structure. Hofmann and Stetzer (1996) found that safety climate varied by supervisor group, that is, the variability between supervisor groups was substantially greater than the variability within such groups. Zohar and Luria (2005) and also other authors (e.g. Huang, Chen, DeArmond, Cigularov and Chen, 2007) referred to a multi-level model of safety. They distinguished responses of workers to questions to capture safety climate at the organizational level from items to capture it at the group level, since the discretion of supervisors of each work group might put into operation management policies differently.

On the basis of all these arguments and combining different approaches to safety climate (see Table 1) the present work identified a questionnaire with three safety climate scales (Organizational, Supervisor and Co-workers scales) and for each scale, using Confirmatory Factor Analysis (CFA) and multilevel confirmatory factor analysis (MCFA), the factor structure was identified on a calibration sample, and confirmed on a validation sample. MCFA was performed, to check if the factorial structure identified with CFA was confirmed also considering multilevel nature of safety climate data.

The main purpose of the present paper is to offer a questionnaire which combines different approaches to safety climate, trying to give a contribute about the theoretical and methodological safety climate issues still open. This questionnaire is addressed to a specific kind of industrial sector, in particular metal-mechanic sector, and to a specific kind of workers, blue-collar workers, with the aim also to offer an adequate diagnostic instrument for safety climate in this kind of setting.

Method

Participants

The present study involved metal-mechanic sector companies taking into account the main sectors which the metal-mechanic belongs to (fabrication of machinery, electrical devices and work vehicles), choosing the types that are considered the most representative on the territories object of the research study.

Regarding dimension, data were collected in small and middle size organizations on the basis of the number of the employees, considering three level sizes: small (from 0 to 120 employees); medium (from 120 to 500); large (500 and beyond).

From the geographical point of view, attention was focused on a specific area, the region of Veneto, a region with a high rate of accidents on workplace and with a high productive reality, particularly in the metal-mechanic sector, which is one of the more relevant industrial sector of this region.

Eight companies agreed to participate in the study, three small, three medium and two large companies, and the 80% of blue-collars of these companies was involved.

A two-level design was used, considering the individual level (level 1) and the work-group level (level 2). All data were collected at individual level, and data collection involved 1617 blue-collars[6]. Considering the group level, for each participant the work-group was registered, and the total number of work-groups in the eight companies was 159. Table 2 shows some characteristics of the eight companies.

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[6] The real number of employees involved in the study was 1744, but 7% of the questionnaires could not be used, because they were not complete, or participants did not understand the language, had reading comprehension problems or were illiterate.

Considering the whole sample, 84% of the participants were male; 83% were Italian workers; 85% had an educational level from 5 to 13 years of school; only 5% of the participants worked in the company from less than 1 year, and 68% worked for the same company from 5 years or more; 70% of participants had a permanent contract. Table 3 shows some characteristics of the participants.

Measure instruments

Safety climate scales development

The first step concerned the identification of the items of the Safety Climate scales, and the process did not involved the participant mentioned above. Referring to some instruments described in the literature (e.g. Zohar & Luria, 2005; Griffin & Neal, 2000; Neal et al., 2000; Melià, 1998; Fugas, Silva and Melià, 2009; Melià, 1998; Melià & Sese, 2007), and choosing items considering peculiar aspects of companies and work-groups, given from interviews with members of the Safety Commissions of the companies, three initial scales were developed: Organizational Safety Climate Scale (OSCS; 18 items), Supervisor Safety Climate Scale (SSCS; 16 items), and Co-worker Safety Climate Scale (CSCS; 16 items), for a total number of 50 items. Also usability of the results by all the stakeholders (top management, supervisors, safety officer, safety commission and unions) was taken into account. Furthermore the necessity of a final instrument which does not need log time to be administered, was also taken into account.

Each item of the three scales was connected to one of the four domains of Griffin & Neal (2000, personal communication): Values, Safety Systems, Communication, and Training.

The items of OSC scale were developed merging items from Zohar & Luria (2005) organizational scale and items from Griffin & Neal (2000, personal communication) scale. Given item redundancy, three judges independently selected items and matched them to the four dimensions (Values, Safety Systems, Communication, and Training). They coded the items in the same way with the exception of three items. They assigned unanimously these three items after discussing about them together.

The first version of SSC scale adopted the group level safety climate scale of Zohar & Luria (2005). The dimension of Training was changed in Coaching, which was more suitable to supervisor role. This dimension refers to supervisor activities concerning supervisor support to worker safety behaviours (i.e. rewards, activities to increase workers safety motivation and knowledge). Three judges independently matched the items to the four dimensions (Values, Safety Systems, Communication, and Coaching). The attribution of one item turned out to be ambiguous, but after a short discussion it was unanimously assigned.

The items of the first version of CSC scale were derived from the adjustment to co-workers of the group level safety climate scale of Zohar & Luria (2005) and comparing the resulted items with items content of co-workers scales by co-workers safety climate literature (e.g. Fugas, Silva and Melià, 2009; Singer et al., 2007; Melià, 1998; Melià and Becerril, 2006; Melià et al, 2008; Jiang et al., 2009). The Griffin & Neal's dimension of 'Training' was changed into 'Mentoring', which was more suitable to the co-workers' role (Ensher, Thomas, & Murphy, 2001). This dimension refers to co-workers' activities oriented to support colleagues to improve their safety behaviour (i.e. giving them suggestions, calling attention to safety). The same three judges independently matched the items against the four dimensions (Values, Safety Systems, Communication, and Mentoring), and only the attribution of two items first resulted ambiguous, but they were unanimously assigned after discussing together.

These three scales were tested in a pilot study with different subjects to discover weak points, and were improved thanks to a qualitative technique, cognitive interview (Willis, 2005). In particular, the method of Verbal probing was used. Considering that study participants were workers from different cultures, sometimes with difficulties in language comprehension and/or production, and in some cases with a very low school level, it was necessary to remove sentence and term ambiguities, and to be sure that each participant comprehends the meaning (Jobe, 2003).

In detail, the first version of the questionnaire with the three scales was given to a first sample of 22 workers of the metal-mechanic sector, with two tasks: the first task was to answer 50 items on a response 7-point Likert scale (from 1 = “never” to 7 = “always”); the second task was to give comprehensibility judgements of each item on a 5-point Likert scale (from 1 = “extremely easy to understand” to 5 = “extremely difficult to understand”). Items that were judged difficult to understand were submitted to a second sample of 15 workers, with the “cognitive interview” technique (Willis, 2005), a qualitative technique for evaluating sources of response error in survey questionnaires, developed through an interdisciplinary effort by survey methodologists and psychologists. This technique explicitly focuses on the cognitive processes that respondents use to answer survey questions; therefore, covert processes that are normally hidden are observed, and these observations permit not only to improve comprehensibility, but even to improve construct validity. In the present study the method of Verbal probing was applied using the 6 basic probes categories identified by Willis for this technique (comprehension/interpretation probe, paraphrasing, confidence judgement, recall probe, specific probe and general probes). After these interviews, a second version of the questionnaire was made, and a third sample of 25 workers gave new comprehensibility judgements on each item; all the items were judged easy or very easy to understand.

This second version was then submitted to a new sample of 113 metal-mechanic workers, and Exploratory Factor Analyses (EFAs) were conducted to explore the factor structure of the three scales, and to decide the final instrument; EFAs were conducted, with maximum likelihood extraction method, Varimax rotation and a number of factors chosen by Kaiser's eigenvalue-greater-than-one rule. The scope was to exclude items that didn't fit well with some theoretical and practical considerations: it was considered important to assess all the four domains (Values, Safety Systems, Communication, Training) not only for theoretical reasons, but also for practical reasons, because these facets were necessary for diagnostic reasons.

No EFA showed the expected four-factor structure, but it is important to say that it should be correct to perform multilevel EFAs, and this was not possible, given the number of participants in this pilot phase (113 participants). EFA results, however, were useful to remove from each of the three scales items with factor loadings too much high in more than one factor, or with low communalities, being understood that it was important to preserve the four-factor structure, with at least three items for each domain[7].

The final Safety Climate scales

At the end of this process, the Safety Climate questionnaire consisted of 41 items (see Table 4): Organizational Safety Climate Scale (OSCS, 17 items), in which the target of the safety climate judgement given by the worker was the entire organization; Supervisor Safety Climate Scale (SSCS, 12 items), in which the workers had to judge their direct supervisor in

[7] Results of the first EFA for the OSC scale showed a three-factor structure, with Values and Safety System item aggregate in one factor. After removing one item, this scale was "forced" in a four-factor structure, that explained the 60% of the variance. The first EFA results on SSC scale showed a one-factor structure. After removing four items, the better solution showed a two-factor structure, with Values and Safety System items, on one hand, and Training and Coaching items, on the other hand, joint together. This solution explained the 76% of the variance. EFA results on CSC scale lead to a two-factor solution, with almost all the items in a main factor, and two of the items concerning values in a second one. After removing four items, the better solution was with one factor, which explained the 59% of the variance.

the work-group; and Co-workers Safety Climate scale (CSCS, 12 items), in which the workers gave their judgements explicitly considering their co-workers inside the work-group. Participants were asked about the extent to which their organization, or their direct supervisor, or their co-workers in the work-group showed to consider safety of workers to be really important.

Each item of the three scales was connected to one of four domains: “Values”, “Safety Systems”, “Communication”, and “Training” (“Coaching” and “Mentoring”, in the case of the SCSS and CSCS). Values sub-scale consisted of items related to the real importance given to safety by management, supervisor and co-workers), for instance: “*Top management considers safety when setting production speed and schedules*”. Safety System sub-scale consisted of items related to the importance that management (supervisor/co-workers) assigns to the safety procedures, practices and equipment connected to safety at work (e.g.: “*Top management provides all the equipment needed to do the job safely*”). The third factor, Communication, consisted of items related to the quality of communication processes concerning safety issues, as in the item: “*Top management listens carefully to workers' ideas about improving safety*”. Training sub-scale considered the importance that management places on safety training, as in the item: “*Employees receive comprehensive training in workplace health and safety issues*”. This factor was called Coaching in the SSCS (e.g. “*My direct supervisor uses explanations to get us to act safely*”) and Mentoring in the CSCS (e.g. “*If it is necessary, my team members use explanations to get other team members to act safely*”). Responses were given on a 7-point Likert scale, from 1 = “never” to 7 = “always”.

Other questions in the questionnaire

At the end of the questionnaire there were also two questions about injuries involvements: number of injuries since the participant has entered the company, and number of micro-accidents in the previous 6 months. Responses were given in absolute number, but were then codified in three classes: 0, 1, more than 1. Also some socio-demographic questions were collected, in particular genre, age, educational level, nationality, length of employment in the company, kind of job-contract, department, work shift at the moment of the survey.

Procedure

Few days before the questionnaire was administered, either during an *ad hoc* meeting organized by the top management with unions, the Safety Commission and the safety officer, or during a trade-union meeting, workers were told that they were part of a larger sample of workers involved in a research study, and received information about the research program. Participants were told that the questionnaire was anonymous, and that all data were collected and conserved by the research group. They were also ensured that only aggregate results would be given to the management of the company.

All participants answered the questionnaire during working hours, at the end or at the beginning of their work shift, and were asked to answer as sincerely as possible. They were told that items concerned with their perception of organizational management, direct supervisor, and work-group co-workers about safety at works; if they found difficulty to answer an item, because they did not know something regarding, for instance, organizational policy, they were told to choose the answer closest to the their perception. At the end of the questionnaire participants had to answer questions about their involvement in injuries and to some socio-demographic questions. Along with the Italian version, English and French versions were also provided for foreign workers. Researchers were available during all time, to help participants, if necessary. All the procedure took about 15 minutes.

Data analysis

To test construct validity, Confirmatory Factor Analysis (CFA) and Multilevel Confirmatory Factor Analysis (MCFA) were performed. While CFA at a single level of analysis analyses the total variance–covariance matrix of the observed variables, MCFA decomposes the total sample covariance matrix into pooled within-group and between-group covariance matrices and uses these two matrices in the analyses of the factor structure at each level. With MCFA it is possible to evaluate a variety of models including those that have the same number of factors and loadings at each level, those that have the same number of factors but different loadings at each level, and those that have a different number of factors at the two levels.

Muthen (1994) suggested that MCFA had to be preceded by four important analysis steps: (1) conventional confirmatory factor analysis on the sample total covariance matrix S_T, (2) estimate between-group level variation, (3) estimation of within structure with confirmatory factor analysis on the sample pooled-within covariance matrix S_{pw}, and (4) estimation of between structure with confirmatory factor analysis on the sample between-group covariance matrix S_b.

Step 1 - Conventional confirmatory factor analysis on the sample total covariance matrix S_T. This step is useful to test different model structures identified in the literature and see which could be more adequate. It is important to remember that the parameters estimates and fit indexes resulting from this step models may be biased when data is multilevel due to the correlated observations, when group sizes are large or when within factor structure is different from between factor structure. Muthen underlined that in any case the test of fit may help the researcher giving an idea of fit.

Step 2 - Estimate between-group level variation. This step helps to understand whether a multilevel analysis is appropriate for the considered data. Before estimate between-group level variation, in the present study some preliminary operations were conducted. First the group size of each group considered was checked. Each group were composed of workers of the same department, of the same shift and with the same supervisor. Groups with less than 4 members were eliminated from the sample. Then homogeneity of climate perceptions was assessed with $r_{wg(j)}$ (Bliese, 2000), deleting groups with $r_{wg(j)}$ lower than critical values identified by Dunlap, Burke and Smith-Crowe (2003). The variability between groups on each item was examined by computing the intraclass correlation (ICC) for each item of the three scales. Muthen (1994) suggested to estimate a unique type of ICC to determine potential group influence. Muthen's ICC index is conceptually similar to ICC(1). The difference between the two indexes is that Muthen's ICC is obtained by random effects ANOVA, while ICC(1) is obtained by fixed effects ANOVA. ICC ranges in value from 0 to 1. If values are close to zero (e.g. .05) the multilevel modelling will be meaningless (Dyer, Hanges & Hall, 2005).

Step 3 - Perform a factor analysis on the sample pooled-within covariance matrix (S_{pw}). S_{PW} matrix is an estimator of the population within-group covariance matrix, and its values reflect the factor structure at the within-group level. When the model estimated using the S_{pw} matrix shows better fit that those of the model estimated using S_T this means that the factor structure differs at the between and at the within level, or that the construct-relevant variance is primarily at the within-group level.

It concerns estimates of individual-level parameters only. As Muthen (1994) affirmed, estimates from S_{PW} model usually are close to the within parameters of the MCFA. This analysis is the preferred way to explore construct variance at the individual level.

Step 4 - Estimation of between structure with confirmatory factor analysis on the sample between covariance matrix S_b. In this step the adequacy of the between-group factor structure is studied. In the present study this matrix is calculated with MPLUS, but it could be created also with conventional software. S_b is the covariance matrix of observed group means, corrected for the grand mean. This correction is obtained multiplying the elements of the matrix by the typical divisor for the covariance matrix (N-1) and then dividing the appropriate divisor (G-1, where G is the number of groups). S_b reflects the between-group population covariance matrix (Dyer et al., 2005). However it is not an unbiased estimator because, for example, it is also a function of the within covariance matrix (Muthen, 1994). When the purposed factor structure is not found using the S_b matrix, an exploratory factor analysis could be performed to find alternative factor structure.

For this study, at the end of these four steps, a multilevel confirmatory factor analysis was conducted[8], testing the alternative models identified in the previous steps. Two levels were considered: group level and individual level. The organizational level was not considered because of the small number of companies which are considered in the study. Therefore, in the multilevel analysis of this research, when perceptions on organizational safety climate are considered, the reader should refer to group perceptions about the organizational safety climate.

For CFA and MCFA, Chi Square values and delta Chi Square values between competitive models are reported. Goodness of fit of the models was evaluated also using the

[8] MCFA was conducted only on the calibration sample because of the too small number of work-groups in the validation sample.

non-normed fit index (NNFI; Bentler & Bonett, 1980), the comparative fit index (CFI; Bentler, 1990), the root mean square error of approximation (RMSEA; Hu & Bentler, 1999), the standardized root mean square residual (SRMR). For NNFI and CFI a value between .90 and .95 is acceptable, and above .95 is good. RMSEA is a global fit measure based on residuals; good models have an RMSEA of .05 or less. Models whose RMSEA is .10 or more have poor fit. RMSEA of .08 is acceptable (Hu & Bentler, 1999). SRMR indicates the closeness of predicted covariances matrix to the observed one; values of zero indicates perfect fit and a value less than .08 is considered a good fit. This measure tends to be smaller as sample size increases and as the number of parameters in the model increases.

Also GFI and AGFI, that are common indexes in many SEM packages, are reported, even if they are affected by sample size and can be large for models that are poorly specified, and the current consensus is not to use these measures (Kenny, 2010 http://davidakenny.net/cm/fit.htm). Values close to .95 reflects a good fit.

Akaike Information Criterion (AIC; Akaike, 1974), Bayesian Information Criterion (BIC; Schwarz, 1978) and Expected Cross-Validation Index (ECVI; Browne & Cudeck, 1989; 1993) were considered to compare different models. The absolute value of these measures have relatively little meaning and they are used to compare the fit of two or more models estimated from the same data set: the focus is on the relative size, the model with the smaller value being preferred.

To test reliability, the most popular coefficient is Cronbach's α, but its use with multidimensional measures is limited (Raykov, 1998; Raykov & Shrout, 2002). In the present study the scales are presumed to be multidimensional, with the scale score representing the underlying factors. In this case its better to use construct reliability (the degree to which the scale indicators reflect an underlying factor), and average variance extracted (AVE, the average percent of variation explained among the items) (Hair, Anderson, Tatham, & Black, 1998). Construct reliability is a measure of reliability and internal consistency based on the square of the total of factor loadings for a construct. An estimate of .70 or above suggests good reliability and therefore that internal consistency exists. Reliability between .60 and .70 may be acceptable. An acceptable level of AVE is .50 or above (Fornell & Larcher, 1981).

All statistical analyses were performed using R Statistical Package (free software available through www.R-project.org), and MPLUS Version 5.1 (Muthen & Muthen, 1998-2008) for Multilevel Confirmatory Factor Analysis (MCFA).

Results

Descriptive statistics

Considering one of the three scales at a time, all cases with missing values were removed[9]. To be sure that this choice did not invalidate our sample, examination of missing values considering the socio-demographic characteristics was made, using chi square test.

At the end of this process, for each item means and standard deviations were computed, and items were also checked for normal distribution, computing skewness and kurtosis and considering normally distributed all the items with values into the range -1/+1.

Organizational Safety Climate Scale

Two hundred and seven cases were removed for this scale (13% of the whole sample), because of missing values. Looking at the distribution of these missing values considering

[9] It was considered more correct, from a psychometric point of view, to perform the CFA using a sample for which estimation of missing values had not to be made.

socio-demographic characteristics of the sample, differences among groups were not strong. Male and female participants had the same proportion of missing values, and no differences were found also among different groups of workers considering the number of years of work experience in the company. There were no differences among age groups except the 25-36 age group, for which only 8% of missing values were found ($p < .01$). Educational level showed an effect on missing values ($p < .001$): Workers with less than 5 years of school showed the 28% of missing values, but it is important to remember that only 76 workers (on 1617) fell in this category. Some significant differences were found for other two socio-demographic characteristics: nationality and kind of contract. For this last characteristic, considering only the two main categories, that is workers with a permanent contract (tenure) and workers with a fixed-time contract, the last ones had more missing values (19%, $p < .01$). In the matter of nationality, foreign workers had more missing values (22%, $p < .001$); also for nationality is important to notice that foreign workers were only 17% of the whole sample (268).

For the 1410 workers without missing values on the Organizational Safety Climate scale, means ranged from 5.54 ($SD = 1.63$), on the item related to the supply of the equipment needed to do the job safely, to 3.29 ($SD = 1.73$) on the item concerning whether top management considers a person's safety behaviour when moving–promoting people. Responses were approximately normally distributed, with skewness ranging from -.87 to .59 and kurtosis values ranging from -1.08 to -.33, indicating a relatively flat distribution. The few values of kurtosis may not be considered as problematic for normality, since the mean of kurtosis values ($|M|=.85$) is less than 1 (Muthen & Kaplan, 1985).

Supervisor Safety Climate Scale

For this scale, only 77 cases over 1617 were removed (5% of the whole sample). No differences in missing distribution were found considering genre, age, educational level, number of years of work experience in the company, kind of contract. Only nationality showed a significant effect on missing values (13% for foreign workers, 3% for Italian workers, $p < .001$); foreign workers, however, as said above, were only the 17% of the whole sample. These results confirmed that removing these cases had no effects on the composition of the original sample.

Considering the 1540 workers without missing values, the item with the lower mean value (2,97, SD 1.96) was the one that take into consideration the possibility that the direct supervisor praise the qualities of workers who pay special attention to safety, where the higher mean value (4.33, SD 1,99) was found for the item stating that direct supervisor is strict about safety rules also when work falls behind schedule. There was a light positive skewness but all values fell inside the range -1/+1 (range from -.02 to .80). Concerning kurtosis values, all items had negative values, from -.59 to -- 1.33, which indicates a distribution more flat than a normal one; for 8 items kurtosis were higher than 1 in absolute value. In this case also the mean of kurtosis values ($|M|= 1.08$) is lightly over 1. This means that responses to all items in the Supervisor Safety Climate scale were symmetrical, but not completely normally distributed regarding their shape.

Co-workers Safety Climate Scale

Only 36 workers had missing values on this third scale (2% of the sample). No effects of socio-demographic characteristics were found on missing values, except for educational level, because workers who attended school for less than 5 years showed a higher number of missing values (8%, $p < .01$) and for nationality: missing values were 6% for foreign workers, and 1,5% for Italian ones. The number of these two socio-demographic categories (foreign workers and workers with very low educational level) were not high, and for this reason the removal of these 36 cases did not modify the characteristics of the sample.

Means and standard deviations were computed on the 1581 workers without missing values. Means ranged from 3.08 (SD 1,72) for the item concerning the possibility that team members speak on safety during the week, to 3.76 (SD 1,89) for the item about the care of peers safety awareness showed by team members. The results showed a very short range of mean responses to the item on co-workers concentrated on the middle of the Likert scale. All items of this scale were normally distributed, with skewness ranging from .25 to .71 and kurtosis ranging from -1 (one item) to -.37. The mean of kurtosis values (|M|= .70) is less than 1.

Construct validity and reliability evaluation

Step 1: CFA

To test construct validity in Multilevel Confirmatory Factor Analysis the first step is a Confirmatory Factor Analysis (CFA). A CFA with maximum likelihood estimation is used with each scale to examine the four-factor model underlying the Safety Climate Scales. Initially, four different models were tested for each of the three scales, as suggested by several authors (e.g. Byrne, 2001; Kline, 1998). The first model (Model 1) consisted in a one-factor model, in which each item was predicted by a unique factor (that is “Safety Climate”, SC). The second model (Model 2) consisted of a four-factors model, without covariances among the four latent factors; the four latent constructs were the four domains: Values (Va), Safety Systems (SS), Communication (Co), and Training/Coaching/ Mentoring (Tr/Coa/Me). Then a four-factor model with covariances among the latent variables (Model 3) was tested. The last model was tested with a second-order CFA, with four latent variable at the first-order level (without covariances), each connected with one latent variable at the second-order level (Model 4), named “Safety Climate”. If neither of the four models showed good fit indexes, other alternative models were explored, according to theoretical issues.

Organizational Safety Climate Scale

The first CFA considered the organizational level. Table 5 shows measures of fit for all the tested models. Model 2 and 3 were not good[10] and are not reported in this table. Nor Model 1, the one with one single factor, neither Model 4, the one with one second-order factor and four first-order factors showed good fit indexes (Mod 1: NNFI = .91; CFI = .92; SRMR = .043; RMSEA = .087; Mod 2: NNFI = .91; CFI = .92; SRMR = .042; RMSEA = .086; so we decided to test a new model, more parsimonious, removing some items from each sub-scale. In Model 5 three items acted as indicators of each of the four latent variables, for a total number of 12 items in the new version of the OSC scale. This model showed a better fit based on chi square value ($\Delta\chi^2_{(68,\ N\ =\ 1019)}$ = 654.7, p < .001), and on AIC, BIC and ECVI measures. All the other fit indexes were good (NNFI = .95; CFI = .96; SRMR = .031; RMSEA = .076). Finally, a higher order factor analysis was conducted, using the same 12 items, with the four first-order safety climate factors acting as indicators of one higher order organizational safety climate factor. This model showed a good fit to the data (NNFI = .94; CFI = .95; SRMR = . 033; RMSEA = .080), although there was a significant decrease in the fit measures of this model compared with the previous model in which the four first-order factors were free to correlate ($\Delta\chi^2_{(2;\ N\ =\ 1019\ )}$ = 46.84, p < .001; higher AIC, BIC and ECVI measures). Correlation

[10] Model 2, the four-factor model without covariances among the four latent factors, had very bad fit indexes and so has not been considered for a comparative evaluation. Model 3, the one with four latent variables and covariances among them, could not be considered because the latent variable covariance matrix was not positive definite, and some of correlations between latent variables were greater than one.

between the original version of the scale (the one with 17 items) and this new short version (12 items) was very high and ($r = .99$, $p < .001$). To verify whether a one-factor model with the same 12 items showed better fit measures, Model 7 was tested. All fit indexes were worse, though acceptable, as it can be seen in Table 5. Standardized factor loadings for Model 6 are shown in Figure 1.

In conclusion, a model with four correlated factors (Values, Safety Systems, Communication, and Training) was the best one — after removing 5 items to obtain better fit indexes. A model with a singular second-order factor comprised of four more specific first-order factors is also plausible. The factors composite reliability coefficients of the four-factor covariance model and of the second-order factor model were above the threshold value for acceptable reliability (Hair et al., 1998). For the four correlated factors, construct reliability and variance extracted (AVE) were: values (.81; AVE .59), safety system (.78; AVE .54), safety communication (.79; AVE .56) and training (.82; AVE .60). For the second-order factor model construct reliability and variance extracted were: values (.81; AVE .59), safety system (.78; AVE .54), safety communication (.79; AVE .56) and training (.82; AVE .60).

The factorial structure of the second-order factor model identified on the calibration sample was tested on the validation sample. The goodness of the factorial structure was confirmed (see table 6): all factor loadings were statistically significant and adequate (all grater than .65 on a standardized solution); fit indexes were acceptable (NNFI = .94; CFI = . 95); the obtained factors composite reliability were above the threshold value (Communication .76, Training .81, Safety System .81 and Values .81). The average variance extracted for each factor was also acceptable: Communication .51, Training .59, Safety System .58 and Values .59.

Supervisor's Safety Climate Scale

The second group of CFA was performed on the scale in which workers had to evaluate their direct department supervisor. SSC scale reflects the extent to which employees believe that safety is important for their direct supervisor. In this scale, as in the OSC scale, a four-factor structure was present in the 12 items (Values, Safety Systems, Communication, Coaching). Table 7 shows measures of fit for all the tested models. Model 2, the four-factor model without covariation among the four latent variables, had very bad fit measures. It was, therefore, not considered any more, and it does not appear in the table. The one-factor model (Model 1) did not show good fit indexes, especially RMSEA (NNFI = .95; CFI = .93; SRMR = .031; RMSEA = .121), as well as Model 3 - the one with four factors free to correlate - even if better than Model 1 ($\Delta\chi^2_{(6;\ N = 1226)} = 27.47$, $p < .001$; NNFI = .93; CFI = .95; SRMR = .031; RMSEA = .108, see also BIC, AIC and ECVI). Model 4 (with one second-order factor and four first-order factors) was worse than the previous one, though still better than Model 1, and RSMEA was not acceptable at all (RMSEA = .115). Looking at estimates of correlations among the four latent variables, it was clear that Values and Safety Systems were very highly correlated, and Communication and Coaching were very highly correlated too. For this reason, in order to find a model that better fits the observed data, a two-factor model with covariances among the two factors was tested, merging Values and Safety Systems on one side, and Communication and Coaching on the other side (Model 5). This model was not good either, and, therefore, two items were removed from the original 12-item scale, one from the original Communication sub-scale, and one from the original Coaching sub-scale. The two-factor model based on 10 items (Model 6) showed good indexes ($\Delta\chi^2_{(19;\ N = 1226)} = 438.26$, $p < .001$; NNFI = .96; CFI = .97; SRMR = .026; RMSEA = .085, see also BIC, AIC and ECVI). The same good fit measures were showed on Model 7, considering the same 10 items, with two first-order safety climate factors acting as indicators of one higher order supervisor safety climate factor. To verify whether a one factor model with the same 10 items showed a better fit, Model 8 was tested. All fit indexes were worse, as it can be seen in Table 7. Standardized factor loadings for Model 7 are shown in Figure 2.

In conclusion, the four-factor structure of the SSC scale was not confirmed by the CFA. Since this factor structure at the group level was not explored by Neal & Griffin (2000) it was not possible to compare our results with their research. In the literature there is not any clear agreement on supervisor safety climate structure, especially on the specific first order factors involved by the second order factor. So the attempt of the present study was to explore the possibility to refer to Zohar supervisor items classified on a structure similar to that one of Neal & Griffin (2000), which allows the researcher to study the global impact of safety climate and some specific diagnostic facets too. Melià & Sesé (2007) and Zohar (2000) found a two-factor structure similar to that which was found in the present study. Melià & Sesè identified a first factor related to supervisor relationship with workers about safety, similar to “Coaching-Communication” factor, and a second factor related to the supervisor's own safety behavior and effort to work safely, similar to “Value-Safety System” factor. Similarly Zohar distinguished a factor on supervisor expectation, which referred to supervisor priority on task issues (e.g. safety versus productivity) and a factor on supervisor action, which referred to supervisor relationship with subordinates (e.g. to supervisor reaction to workers conduct as positive and negative feed-back). The new structure with two correlated factors – after removing two items – and the model with a singular second-order factor comprised of the two more specific first-order factors seem to be the most plausible ones to pursue this approach. The average scale score provides the climate level parameter which resulted in highly significant correlation between the original scale with 12 items and the second with 10 items was very high (r = .996, p<.001).

For the two correlated factors model and the second-order factor model construct reliability and variance extracted (AVE) were the same: values-systems (.93; AVE .70), coaching-communication (.91; AVE .72).

Also for this scale the factorial structure of the second-order factor model identified on the calibration sample was tested on the validation sample. The factorial structure resulted validated (see Table 6): all factor loadings were statistically significant and adequate (all grater than .73 on a standardized solution); fit indexes were acceptable (NNFI = .92; CFI = .94). RMSEA value was over the acceptable threshold (.08), however SRMR value (.05) indicated a good fit. The obtained factors composite reliability was above the critical threshold: Values-Safety System .92 and Communication- Coaching .90. The average variance extracted for each factor was also acceptable: Values-Safety System .67 and Communication- Coaching .70.

Co-workers' Safety Climate Scale

The third CFA focused on co-workers as ‘‘agents” of the safety climate actions or omissions. Table 8 shows measures of fit for all the tested models (Model 2 is not reported in this table). Model 2, the four-factors model without covariances among the four latent factors, had very bad fit indexes and so has not been considered for a comparative evaluation.

Not even Model 1, the one with one single factor, showed good fit indexes (NNFI = .89; CFI = .91; SRMR = .043; RMSEA = .125). Model 3, the one with four latent variables and covariances among them, showed better fit indexes based on chi square value ($\Delta\chi^2_{(48,\ N = 1154)}$ = 433,47, p < .001) and on AIC, BIC and ECVI measures than Model 2. All the other fit indexes were good (NNFI = .95; CFI = .96; SRMR = .029; RMSEA = .083). Then a higher order factor analysis was conducted, with the four first-order safety climate factors acting as indicators of one higher order co-workers safety climate factor. Just like the previous one, this model also showed a good fit to the data (NNFI = .95; CFI = .96; SRMR = .031; RMSEA = .086), although there was a little decrease in the fit of this model compared to the previous one, in which the four first-order factors were free to correlate ($\Delta\chi^2_{(50,\ N\ =\ 1154)} = 480.82$, $p < .001$; higher AIC, BIC and ECVI measures). Finally, Model 5, one higher-order factor with two first-order factors, the factor structure identified for the supervisor safety climate scale, was tested but the decrease was so strong in the fit of this model that it has not been considered for a comparative evaluation. Standardized factor loadings for Model 4 are shown in Figure 3.

In conclusion, both Model 3, the four factor model with covariations among factors, and Model 4, the one with one second-order factor and four first-order factors, showed the best fit to the data.

As for the other scales, this equivalence between these two models, namely, one with covariations among factors and the other with a second-order factor, allows the researcher to choose the second-order factor structure to determine the overall impact of the safety climate agent's scale on safety outcomes and to choose the other model to determine the impact of distinct agent practices on task performance.

The factors composite reliability coefficients of the four factor covariance model and of the second-order factor model were above the threshold value for acceptable reliability (Hair, Anderson, Tatham, & Black, 1998). For the four correlated factors construct reliability and variance extracted were: values (.84; AVE .63), safety system (.90; AVE .75), safety communication (.86; AVE .67) and mentoring (.87; AVE .68). For the second-order factor model construct reliability and variance extracted were: values (.84; AVE .63), safety system

(.90; AVE .75), safety communication (.86; AVE .67) and mentoring (.87; AVE .68).

As shown in Table 6, analysis on the validation sample confirmed also for the Co-workers Safety Climate scale the factorial structure of the second-order factor model. All factor loadings were statistically significant and adequate (all greater than .74 on a standardized solution); fit indexes were acceptable (NNFI = .94; CFI = .95); the obtained factors composite reliability was above the threshold value (Communication: .83, Mentoring: .90, Safety Systems: .91, Values: .85). The average variance extracted for each factor resulted acceptable (Communication: .63, Mentoring: .74, Safety Systems: .77, Values: .65).

Step 2: estimate between-group level variation

Organizational Safety Climate Scale

Prior to conducting the MCFA some preliminary analysis was done. After the exclusion of work groups with less than four members, 85 groups remained. Then groups with $r_{wg(j)}$ less than critical values identified by Dunlap et al. (2003) were excluded. After which a sample of 896 workers in 77 work groups remained. As shown in Table 9, ICC(1) for each of the observed items ranged from .13 to .21. These values underlined the importance of conducting an MCFA because of the affection of group membership to individual level observation.

Supervisor Safety Climate Scale

Having excluded work groups with less than 4 members and with $r_{wg(j)}$ lower than critical value, the sample for this scale was composed of 718 workers in 53 work groups. ICC(1) for each item were very high, from .22 to .35 (see table 9), highlighting the importance of conducting MCFA also for this scale.

Co-workers Safety Climate Scale

After excluding work groups with less than 4 members and with $r_{wg(j)}$ lower than critical value, the sample for CSC scale was composed of 855 workers in 65 work groups. ICC(1) for three items was under .10 (see table 9), but it ranged from .07 to .18 with a mean and median value of .12.

Steps 3 and 4: estimation of within and between structure with CFA

For each scale, the CFA model with the best fit identified in step 1 was analysed with. and on between covariance matrix S_b. In step 4 more models were tested because of the poor fit of factor structure identified in step 1 CFA.

Since factor loadings at steps 3 and 4 were very close to those ones respectively at within level and between level in multilevel confirmatory factor analysis, they are not reported in this section.

Organizational Safety Climate Scale

As shown in Table 10, fit indexes in step 3 are worse than fit indexes at step 1. Dyer et al. (2005) explained it saying that this happens because step 1 results on the total covariance matrix also had the contribution of systematic between-group relationships which was removed from step 3 pooled-within covariance matrix. This underlines the importance of between-group level analysis. From a comparison between factor loadings of steps 1 and 3, step 3 parameters estimates were smaller than step 1 estimates, confirming the importance of between-group contribution. At step 4 the work- group-level factor structure was analyzed. Because of the poor fit of second-order model identified at step 1, the four-factor structure and the one-factor structure were also explored. For all these models fit indexes were very poor. This could depend on the fact that the proposed factor structures did not fit the data very well. However, as it will be shown in the next section, MCFA results seemed adequate, supporting the idea that the between-level factor structure was highly influenced by the within level modeling. In the literature, however, no reference was found supporting this hypothesis.

Supervisor's Safety Climate Scale

Table 11 shows CFA results for the step 3 two-factor model on the pooled-within covariance matrix. The fit indexes are good (NNFI=.97; CFI=.96). As for OSC scale, indexes (e.g. CFI=.97 in step 1) were a little lower than ones for the same model on the total covariance matrix. The same trend with lower values was also found for factor loadings, indicating the importance of between level analysis. Many factor structures were tested for Step 4 (e.g. two-factor structure, one second-order factor structure and one-factor structure), but, as for the previous scale, no one showed acceptable indexes. The same hypothesis of explanation identified for OSC scale was supported also in this case.

Co-workers' Safety Climate Scale

Fit indexes of CFA that resulted at step 3 were very similar to the ones of step 1 (see Table 12). As for SSC model fit well (NNFI=.96; CFI=.97). RMSEA value was a little high (.07), but lower than RMSEA values of step 1. Parameters estimates were lower than those at step 1, showing the role of between-matrix contribution to improve model fit at the individual level. As for the previous scales, it seemed very difficult to identify an adequate structure for the between covariance matrix. In this case, many factor structures were also tested (e.g. four-factor structure, one second-order factor structure and one-factor structure), but none produced acceptable indexes.

Multilevel Confirmatory Factor analysis

In the present study, four multilevel measurement models for each scale, chosen after step 3 and step 4 analyses, were examined. The first model consisted of four factors (two for SSC scale) with covariations for individual-level and group-level, with item loadings freely estimated across levels. Model 2 consisted of one second order factor and four first-order factors (two for SSC scale) for each level, with item loadings freely estimated across levels. Model 3 consisted of four factors (two for SSC scale) with covariations for individual-level and one second order factor and four first-order factors (two for SSC scale) for group-level. Model 4 consisted of one second order factor and four first-order factors (two for SSC scale) for individual-level and four factors (two for SSC scale) with covariations for group-level. For OSC scale also another model was considered which consisted of one second order factor and four first-order factors at the individual-level and a one-factor model for the group-level.

Organizational Safety Climate Scale

Table 13 shows measures of fit for all the tested models (Model 1, 3 and 4 are not reported in this table, because they did not work). Model 1 (four-factors with covariances among the four latent factors at individual and group level), Model 3 (four factors with covariations at individual-level and one second order factor and four first-order factors at group-level) and Model 4 (one second order factor and four first-order factors at individual-level and four factors with covariations at group-level) could not be considered because the latent variable covariance matrix was not positive definite, and some correlations between latent variables were greater than one. Model 2, the model with one second order factor and four first-order factors for each level, showed acceptable fit indexes (NNFI = .92; CFI = .93). Nevertheless SRMRb (.078) was high, showing that perhaps at the between level another factorial structure could be more appropriate. For this reason, a model with one factor at the between level was tested (Model 5). Fit indexes were a little lower than the those of Model 2 (NNFI = .92; CFI = .91), SRMRb was better (.054), but RMSEA is worse (.063) and also BIC was greater than that one of Model 2. Standardized loadings for Model 2 and Model 5 are shown in table 14. Results support the model with one second-order factor and four first-order factors at the individual level, identified by the step 3 analysis, too. The path diagram of Model 2 is displayed in Figure 4. Results for the factor structure at the work-group level showed the adequacy of either a second-order factor structure or a one-factor structure, but the first one seemed a little better also on step 4 CFA. The items of second-order model load strongly at within and between level. Between-level loadings were stronger than those at individual level, underlining the importance of the group level for climate scales.

Supervisor's Safety Climate Scale

As shown in table 15, results for all the models considered in analyzing SSC scale were very good. The adequacy of both the second-order factor with two first-order factor model or the two-factor model confirmed the findings of the CFA. From the analysis at steps 3 and 4 and the comparison of the four models analyzed with MCFA, the best model seemed to be Model 3, the one with a two-factor structure at the individual level and a second-order structure at the between level: NNFI and CFI were higher (respectively .96 and .97) than those of the other models; RMSEA and SRMRw were a little better; AIC was smaller (214.8), so as BIC and ECVI. For this model, at the individual level, loadings ranged from .73 to .88. As for OSC scale, factor loadings at the between level were higher than those at the individual level, showing the theoretical importance of MCFA for work-group safety climate. Standardized loadings for Model 1 and Model 3 are shown in table 16. The path diagram of Model 3 is displayed in Figure 5.

Co-workers' Safety Climate Scale

As for OSC scale, at first the four-factor structure model was estimated, but could not be considered because the latent variable covariance matrix was not positive definite, and some of correlations between latent variables were greater than one.

Model 2, the model with one second-order factor and four first-order factors for each level, showed good fit indexes (NNFI = .94; CFI = .95), but also in this case SRMRb is high (.090), showing that at the between level perhaps another factorial structure could be more appropriate (see table 17). Model 3 indexes were very similar to those of Model 2 (NNFI = . 94; CFI = .96; SRMRw = .031 and SRMRb = .081; RMSEA = .053). Model 4, the one with one second-order factor and four first-order factors at individual-level and four factors with covariations at group-level, showed an improvement (NNFI = .95; CFI = .96; SRMRw = .035 and SRMRb = .056; RMSEA = .051), confirmed from BIC, AIC and ECVI indexes too. Standardized loadings for Model 4 are shown in Table 18. As for the other scales, the between level loadings were very high. The path diagram of Model 4 is displayed in Figure 6.

In conclusion all the compared models showed acceptable fit indexes but the one which seemed to fit better data structure is Model 4, showing that for the co-workers' safety scale two different factorial structures had to be used, at individual-level and at group-level, to incorporate properly the multilevel nature of data.

Criterion-related validity

A further step in the process of validation of the safety climate scales concerned the analysis of criterion-related validity. To do this, participants were divided into three groups, on the basis of their answers to the items related to injuries ("*How many injuries have you had since you have entered this company?*") and micro-accidents (Zohar, 2000) ("*How many micro-accidents have you had in the last 6 months?*"). On the base of number of injuries and micro-accidents, participants were codified, for each variable, in three classes: "none", "one", and "more than one", and mean values on the three safety climate scales were computed for these three groups. Six different ANOVA were conducted, analysing mean safety climate scores differences among the three groups.

Considering injuries, mean scores on each of the three scales were significantly different in the three groups (OSC scale: $F_{(2,1599)} = 22.4$, $p < .001$; OSC scale: $F_{(2,1596)} = 17.1$, $p < .001$; CSC scale: $F_{(2,1598)} = 10.1$, $p < .001$). Post-hoc analyses (Bonferroni) showed that for the SSC scale each mean group was different from the others, whereas for OSC scale and CSC scale mean scores for groups with none or one injury did not differ, but were different from mean scores for the group with more than one injury. All these significant differences showed that mean scores in safety climate scales were lower for groups with more injuries.

Considering micro-accidents, mean scores on OSC scale and SSC scale were significantly different in the three groups (OSC: $F_{(2,1600)} = 19.1$, $p < .001$; SSC: $F_{(2,1597)} = 10.6$, $p < .001$), but on CSC scale mean scores were not significantly different in the three groups. Post-hoc analyses (Bonferroni) showed that for OSC scale each mean group was different from the others, whereas for SSC the only significant difference was between the "none" group and the "more than one" group. Even in this case, as for injuries, safety climate mean scores were lower for groups with more micro-accidents.

In conclusion, differences among groups by self-report injuries and micro-accidents indicated that Organizational Safety Climate scale and Supervisor Safety Climate scale were negatively related with the injuries and micro-accidents involvements. The third scale, Co-worker Safety Climate scale, was negative related with injuries but not with micro-accidents.

Discussion and conclusions

Safety climate is universally regarded as an important construct that represents the "subjective" side of organizational safety and has a huge impact on workers attitudes, behaviours and, ultimately, on work accidents. Safety climate reflects the surface features of the safety culture found in employees perceptions at a given point in time and is an indicator of the underlying safety culture of an organization and/or a work group (Flin et al., 2000; Melià et al. 2008). It corresponds to workers perceptions about safety level (policies, procedures, and practices) in the organization and in the work groups as transmitted by the management, co-workers and supervisors. Given the important role of safety climate in predicting safety behaviours, it is important to translate this concept into an operational measure, either for theoretical or practical reasons. The proliferation of assessment instruments for safety climate, having many differences among them, is probably due to the lack of a unifying theoretical model and emphasizes the need of answering to some questions about the way to assess safety climate.

The present study proposes an instrument that, starting from well-known safety climate measures, effort to operationalize and validate a safety climate questionnaire with a factor structure, that reflects specific content dimensions (e.g. values; training; communication) and which considers the safety agents' point of view (organization, supervisor and co-workers). This is also a the first attempt to validate safety climate scales with multilevel confirmatory factor analysis with Muthen approach (1994), treating the data, collected from an individual survey, not as completely independent, given their nested nature, but decomposing the variance into between-group and within-group estimates. Moreover, the procedure we used intended to support the development and validation of a questionnaire customized for blue-collar workers and suitable for industrial sector.

The selected content dimensions and the focus on different agents departed from well-know questionnaires (e.g. Griffin & Neal, 2000; Melià et al., 2008; Zohar & Luria, 2005), and where selected in order to represent safety climate specific facets and considering its adequacy for representing the safety climate construct. To increase the coherence between construct definition and operationalization, qualitative techniques have been used in support of the quantitative ones.

Overall, the questionnaire aimed to fulfil theoretical and methodological gaps in the assessment of safety climate, but had the objective, at the same time, of meeting stakeholders (as companies and workers) perspectives and needs and of being useful as a diagnostic tool that helps to identify detailed problems critical to improve safety at work.

Several procedures were used to try to achieve this result. The preliminary phase involved the item choice for the three scales (one separate scale for each climate agent, considering organizational and group level, and at the group level the two main agents, that is supervisor and co-workers) and their assessment by three judges, to determine which facet of the safety climate construct was represented by each item. In the second step, the scales were tested in a pilot study, involving 175 blue-collar workers, to assess the level of comprehension of the items and to improve construct validity through 15 cognitive interviews. Cognitive interviewing technique aimed to verify, whether the response was in line with what a specific item should assess, exploring the underlying cognitive process that leads to a given item response; results of these interviews helped us to change the written formulation of some items. Exploratory factor analysis was then used to decide write the final version of the scales, with particular reference to which item did not works and had to be removed from the scale.

In the main analytical phase, 1617 blue-collar workers were involved, in 8 companies, and several analysis were conducted, using Structural Equation Modelling. One of the aims of the study was to develop a measurement instrument which could be useful, on one hand, to determine the overall impact of safety climate, and, on the other hand, to measure the specific features of safety climate for more detailed diagnostic information; for this reason, confirmatory factor analyses were performed, comparing first order with second order latent factorial structures. The factorial structure of each scale was explored using a calibration sample of 7 companies, and the best structures were validated on a different sample, that is a large new company; this procedure was useful to confirm the stability of the previous results. The process of construct validation ended with a multilevel confirmatory factor analysis which considered the respondents nested into work groups.

The analysis of criterion-related validity, with injuries and micro-accidents as criteria, was used to demonstrate the link between the Safety Climate scales and the presumed connected outcomes in the work situation.

At the end of this process, the final version of the questionnaire we are proposing has 34 items, 12 for Organizational Safety Climate, 10 for Supervisor Safety Climate, and 12 for Co-workers' Safety Climate. The OSC scale evaluates four dimensions of safety climate: values, safety systems, communication and training, with 3 items for each dimension. The SSC scale includes two sub-scales, one for supervisor's reaction to the workers' safety behaviours (4 items), and the second for supervisor's own effort to improve safety (6 items). The CSC scale measures four dimension, each with three items (values, safety systems, mentoring). The final version of the safety climate questionnaire, with a short description of the items, is shown in Table 19.

Multilevel confirmatory factor analysis seemed to be the adequate kind of analysis to verify safety climate construct validity.

OSC shows a hierarchical structure in which a singular, higher order factor is comprised of more specific first order factors, either at the individual and at the group level. SSC and CSC better models have some little differences, as such hierarchical structure was found at the group level for SSC and at the individual level for CSC. The individual level of SSC and the group level of CSC confirm the presence of some specific safety climate factors, not hierarchically connected with a superordinate second order factor, but strongly connected among them. It is important to note, that the one-factor models always showed worse results, and models with one second order factor and some first order factors always showed very good fit indexes, even when they were not the better models. This structure confirms the purpose of Griffin & Neal (2000).

These factors are similar for OSC and CSC, while SSC shows a two factor structure, with the original four safety climate facets joint together underlying a relational factor (the original safety communication and safety training factors) and a personal effort factor (the original safety values and safety systems factor). Although this structure is very similar to that one identified by Melià & Sesè (2007), and by Zohar (2000). All final models have very good fit indexes, confirming the adequacy of the proposed factor structure for all the three scales, especially for SSC scale and CSC scale. These factor structures appear useful not only for research scopes, but also for providing more detailed diagnostic information to the companies.

Reliability of the scales, evaluated by computing construct reliability and average variance extracted (in place of most popular Cronbach's α, given the multidimensionality of the scales), shows very high levels.

The Criterion-related validity appears good: the more the safety climate scores, the less the self-report number of injuries and micro-accidents. The group of workers with no injuries showed a safety climate score – in all the three scales – higher than the group with more than one injury; for micro-accidents, the situation is similar, except for CSC score.

In our opinion, these results are relevant, because they confirm the theoretical structure of safety climate purposed from Griffin and colleagues, using not only considering psychological climate (that is, the individual level), but also the group level safety climate. The clear distinction, made with the use of three different scales, among safety agents (organization, supervisor, co-workers), gives an instrument that can assess workers' perceptions focused on each level, without sources of confusion for the respondents and giving a picture of state of safety for each level. This instrument allows to deeply explore, for instance, lateral relationships of supervisor's safety climate and co-workers' safety climate, analysing the interactions between the roles of these two safety agents. These interactions did not receive much attention in previous safety climate researches.

This work purposes, for the first time, a validation of safety climate scales using MCFA. However, it was not possible to use the third level of analysis, that is the company level, because of the small number of companies participating in the survey. This limit is the probable explanation of the fit results for OSC scale models, which appear to be slightly worse than the ones derived from the other two scales. Future studies, focusing on a new survey, would increase the number of companies and work group and allow to perform the MCFA also on a validation sample and, in addition, to use a multilevel approach covering the three levels (company level, work group level and individual level).

In conclusion, in this article we present the research which led to the development of a new questionnaire suitable for blue-collar workers and to the confirmation of its validity, reliability and usefulness to measure safety climate in the industrial sector.

Table 2.1

Different approaches concerning safety climate scale

	Melià (1998, 2002, 2007, 2008)	Zohar (2000, 2005, 2008)	Griffin & Neal (2000, 2004, personal communication)	Present study
Levels	- Organizational level - Group level (supervisor, co-workers) - Individual level	- Organizational level - Group level (supervisor)	- Organizational level	- Organizational level - Group level (supervisor, co-workers)
Themes	Org. safety response (OSR) (e.g. priority of safety on other competing goals, inspections); Supervisor safety response (SSR) (e.g. priority of safety on other competing goals, communication); Co-workers' safety response (CSR) (e.g. priority of safety on other competing goals); Workers safety response (WSR) (evaluation of safe and unsafe behaviours of workers)	Organizational safety climate: management commitment to safety, priority of safety over competing operational goals; Group safety climate: priority of safety versus competing goals	Safety climate as a higher order factor comprised of more specific first order factors. Higher order factor concerns the extent to which employees believe that safety is valued within organization. First order factors reflect perceptions of safety related policies, procedures and rewards.	Safety climate as a higher order factor comprised of more specific first order factors. Higher order factor concerns the extent to which employees believe that safety is valued within organization. First order factors reflect perceptions of safety related policies, procedures and rewards.
Dimensions	OSR (the presence of safety structures, fulfilment of safety rules, safety inspections, safety training and information, safety meetings, promotional campaigns, safety incentives and sanctions); SSR, CSR and WSR (providing models of safe or unsafe behaviour through their own safe or unsafe behaviour, reactions to the safe or unsafe behaviour of the worker, active encouragement of safety);	Organizational safety climate: active management practices, proactive practices, declarative action; Group safety climate: active practices, proactive practices, declarative action;	Griffin & Neal (2000) second study: manager values, safety communication, safety practices, safety equipment, personnel training; Griffin & Neal (personal communication): manager values, safety communication, safety systems, safety training;	Griffin & Neal (personal communication): manager values, safety communication, safety systems, safety training;
Items	Melià (1998): OSR (14 item), SSR (7), CSR (7) and WSR (7); Melia et al.(2008): OSR (10 item), SSR (8), CSR (8) and WSR (7);	Zohar &Luria (2005): Organizational safety climate (16 items), Group safety climate (16 items)	Griffin & Neal (2000) second study(18 items): manager values (4), safety communication (4), safety practices (3), safety equipment (3), personnel training (4); Griffin & Neal (personal communication) (16 items): manager values (4), safety communication (5), safety systems (3), safety training (4);	OSC scale (17 items combining items from Zohar & Luria (2005) organizational level sub- scale and Griffin & Neal (personal communication); SSC scale(12 items) adjusting items of Zohar & Luria (2005) sub-scale with those of Melia & Sese, 2007; CSC scale(12 items) inspired by Zohar & Luria (2005) supervisor scale and by co-workers response scale of Melià et al. (2008)

	Melià (1998, 2002, 2007, 2008)	Zohar (2000, 2005, 2008)	Griffin & Neal (2000, 2004, personal communication)	Present study
Data analysis	Uni-level statistical analyses	Multilevel statistical analyses	Uni-level statistical analyses	Multilevel statistical analyses
Structure	Supervisor response (Melià &Sese, 2007: identification of two first order factors (supervisors' response toward workers' safety behaviour and supervisors' self-applied safety response) or one first order factor by Confirmatory Factor Analysis;	Org. SC: Identification of three factors (Monitoring-Enforcement, Learning-Development, Declaring-Informing) or one global factor by EFA; Group SC: Identification of three factors (Active practices (Monitoring-Controlling), Proactive practices (Instructing-Guiding), Declarative practices (Declaring-Informing)) or one global factor by EFA;	Identification of One second order global factor and four first order factors or four first order factors with covariances between them by Confirmatory factor analysis (Griffin & Neal, 2000)	Identification of One second order global factor and four first order factors or four first order factors with covariances between them by Confirmatory factor analysis (Griffin & Neal, 2000)
Specific facets selected for the present study	- Attention to select items which allow to analyse different agents' safety responses. - Analysis of safety climate statements from the point of view of the agent that performs or is responsible for the safety activity or issue involved (organization, supervisors, co-workers, workers)	- Attention to select items which concerns properly to safety climate. - Multilevel statistical analyses of safety climate.	Attention to identify safety climate specific dimensions and safety climate factor structure.	All the specific facets identified in Melià, Zohar and Griffin & Neal approaches

* Table 2.1 (continue) Different approaches concerning safety climate scale

Table 2.2
Characteristics of the companies

Company	Products	Company Size	Work-groups	Participants	% of Participants on the total number of the blue-collars	Micro-accidents in the last 6 months (% of one ore more, self-report)	Injuries in the company (% of one ore more, self-report)
1	Electric and petrol driven chainsaws, brush cutters and hedge cutters.	large	49	540	55%	17%	31,00%
2	Metal forniture for super- and hyper-markets	small	13	81	85%	41%	37%
3	Cooling, conditioning and purifying systems	medium	10	114	95%	17%	34%
4	Electrodes and metal wires	small	6	32	90%	19%	34%
5	Excavators and Trucks	medium	13	224	88%	6%	53%
6	Refrigerating systems	small	13	90	90%	34%	40%
7	Refrigerating systems	large	41	432	79%	13%	59%
8	High and low voltage products and systems	medium	14	104	75%	12%	33%
tot			159	1617	80%		

Table 2.3
Characteristics of the participants

Variables		N	%
Gender	male	1356	84%
	female	257	16%
Age	18-25	104	6%
	26-35	345	21%
	36-45	611	38%
	46-55	438	27%
	> 55	81	5%
Nationality	Italian	1345	83%
	foreign	268	17%
Educational level	< 5 y	76	5%
	5 – 8 y	686	42%
	9 – 13 y	684	42%
	> 13 y	150	9%
Years of work experience in the company	< 1 y	83	5%
	1- 5- y	377	23%
	> 5 y	1104	68%
Injuries involvements in the company in the last 2 years	none	917	57%
	one	369	23%
	more than one	316	20%
Micro-accidents in the last 6 months	none	1339	83%
	one	129	8%
	more than one	135	8%

Table 2.4

Dimensions of the three safety climate scales at the end of the developing process

Organizational Safety Climate (OSC) Scale	Supervisor's Safety Climate (SSC) Scale	Co-workers' Safety Climate (CSC) Scale
Management Safety Values (4 items)	Supervisor's Safety Values (3 items)	Co-workers' Safety Values (3 items)
Safety Systems (5 items)	Safety Systems (3 items)	Safety Systems (3 items)
Safety Communication (4 items)	Safety Communication (3 items)	Safety Communication (3 items)
Safety Training (4 items)	Safety Coaching (3 items)	Safety Mentoring (3 items)

Table 2.5.
Confirmatory Factor Analysis for Organizational Safety Climate Scale: Fit indexes for five models

Model	Mod 1	Mod 4	Mod 5	Mod 6	Mod 7
Model description	One factor model (17 items)	One second order factor and four first order factors (17 items)	Four factor model with covariations among factors (12 items)	One second order factor and four first order factors (12 items)	One factor model (12 items)
χ^2	1033.035	985.9	331.21	378.05	454.86
df	113	116	48	50	54
p-value χ^2	.000	.000	.000	.000	0
$\Delta\chi^2$	10184.69*	47.14	654.68	46.84	76.81
df $\Delta\chi^2$	23	3	68	2	4
p-value $\Delta\chi^2$	.000	.000	.000	.000	.000
NNFI	.906	.908	.946	.940	.932
CFI	.918	.922	.961	.954	.944
RMSEA (C.I)	.087 (.082 – .092)	.086 (.081 – .091)	.076 (.068 – .084)	.080 (.073 – .088)	.085 (.078 – .093)
SRMR	.043	.042	.031	.033	.036
GFI	.878	.884	.948	.941	.928
AGFI	.843	.847	.916	.908	.896
BIC	1268.54	1242.18	539.01	572	621.1
AIC	1113.04	1059.90	391.21	434.05	502.86
ECVI	1.093	1.04	.384	.426	.49

*In the case of Model 1, $\Delta\chi^2$ refers to the comparison between Model 1 and the Null Model.

Table 2.6
Confirmatory Factor Analysis in the validation sample:
Fit indexes for three scales

Fit indexes	OSC scale	SSC scale	CSC scale
χ^2	215.7	239.6	247.37
df	50	34	50
p-value χ^2	0	0	0
NNFI	0.94	0.92	0.94
CFI	0.95	0.94	0.95
RMSEA (C.I)	0.082 (0.071-0.094)	0.121 (0.107-0.136)	0.096 (0.084 – 0.108)
SRMR	0.04	0.05	0.04
GFI	0.93	0.89	0.91
AGFI	0.89	0.83	0.86
BIC	389.25	366.14	416.96
AIC	271.7	281.6	303.37
ECVI	0.55	0.68	0.71

Table 2.7

Confirmatory Factor Analysis for Supervisor Safety Climate Scale: Fit indexes for seven models

Model	Mod 1	Mod 3	Mod 4	Mod 5	Mod 6	Mod 7	Mod 8
Model description	One-factor model (12 items)	Four-factor model with covariations among factors (12 items)	One second-order factor and four first- order factors (12 items)	Two-factor model with covariations among factors (12 items)	Two-factor model with covariations among factors (10 items)	One second-order factor and two first- order factors (10 items)	One-factor model (10 items)
$\chi2$	948.471	678.01	798.86	746.1	307.83	307.83	642.62
df	54	48	50	53	34	34	35
p-value $\chi2$	.000	.000	.000	.000	.000	.000	.000
$\Delta\chi2$	11997.53*	27.47	12.85	52.76	438.26	.00	334.79
df $\Delta\chi2$	12	6	2	3	19	0	1
p-value $\Delta\chi2$	.000	.000	.000	.000	.000	n.s.	.000
NNFI	.951	.933	.923	.933	.964	.964	.921
CFI	.931	.951	.951	.946	.972	.972	.939
RMSEA (C.I)	.121 (.115 – .128)	.108 (.101 – .115)	.115 (.108 – .123)	.108 (.101 – .115)	.085 (.076 – .093)	.085 (.076 – .093)	.124 (.116 – .133)
SRMR	.035	.031	.034	.032	.026	.026	.036
GFI	.858	.904	.886	.893	.948	.948	.88
AGFI	.759	.84	.821	.843	.916	.916	.810
BIC	1117.11	888.8	995.6	921.76	455.39	455.39	783.15
AIC	996.47	738.005	854.86	796.1	349.83	349.83	682.62
ECVI	.813	.602	.698	.650	.286	.286	.557

*In the case of Model 1, $\Delta\chi^2$ refers to the comparison between Model 1 and the Null Model.

Table 2.8
Confirmatory Factor Analysis for Coworkers safety climate scale:
Fit indexes for three models

Model	Mod 1	Mod 3	Mod 4
Model description	One-factor model (12 items)	Four-factor model with covariations among factors (12 items)	One second-order factor and four first-order factors (12 items)
χ^2	1019.58	433.48	481.22.00
df	54	48	50
p-value χ^2	.000	.000	.000
$\Delta\chi^2$	9789.15*	586.11	47.34
df $\Delta\chi^2$	12	68	2
p-value $\Delta\chi^2$	.000	.000	.000
NNFI	.89	.95	.95
CFI	.91	.96	.96
RMSEA (C.I)	.125 (.125 – .131)	.083 (.076 – .091)	.086 (.079 – .094)
SRMR	.044	.029	.031
GFI	.86	.94	.93
AGFI	.79	.90	.90
BIC	1188.81	645.01	678.25
AIC	1067.58	493.48	536.82
ECVI	.926	.428	.466

*In the case of Model 1, $\Delta\chi^2$ refers to the comparison between Model 1 and the Null Model.

Table 2.9
Inter Class Correlations values for items of each scale

OSC scale		SSC scale		CSC scale	
Item	ICC(1)	Item	ICC(1)	Item	ICC(1)
D1.02. Space to discuss in meeting (Communication)	.13	D2.01. Supervisor safety rules care when a delay in production schedule occurs (Values- S. Systems)	.22	D3.01. Team members emphasis to peers on safety care when under pressure (Mentoring)	.10
D1.03. Information supply on safety issues (Training)	.19	D2.02. Supervisor discusses with workers on safety improvement (Coaching-Communication)	.25	D3.02. Team members safety care at the shift end (Values)	.17
D1.05. Management attention to workers ideas to improve safety (Communication)	.15	D2.03. Supervisor care to workers safety awareness (Coaching-Communication)	.29	D3.03. Team members care of peers safety awareness (Mentoring)	.14
D1.07. Management safety care in production schedule (Values)	.18	D2.04. Supervisor coaching about safety care (Coaching-Communication)	.27	D3.04. Team members mentoring to peers about working safely (Mentoring)	.11
D1.08. Management effort on safety improvement (S. Systems)	.21	D2.05. Supervisor praise to very careful safety behaviours (Coaching-Communication)	.18	D3.05. Team members speaking on safety on the week (Communication)	.08
D1.09 Investments on safety training (Training)	.20	D2.06. Supervisor care to provide workers needed safety equipment (Values- S. Systems)	.32	D3.06. Team members discussing about incident prevention (Communication)	.09
D1.10. Management safety care in moving-promoting people (Values)	.17	D2.08. Supervisor care to the use of safety equipment (Values- S. Systems)	.35	D3.07. Team members care to others workers safety equipment (S. Systems)	.10
D1.11. Management reaction to solve safety hazard (S. Systems)	.19	D2.09. Supervisor safety rules care when workers are tired (Values- S. Systems)	.26	D3.08. Team members safety care when tired (Values)	.15
D1.12. Workers consultation on safety issues (Communication)	.15	D2.10. Supervisor care to all safety rules (Values- S. Systems)	.33	D3.09. Team members discussion about safety hazard (Communication)	.07
D1.14. Management safety care on a delay in production schedule (Values)	.16	D2.11. Supervisor control the compliance of all the workers (Values- S. Systems)	.29	D3.10. Team members remind safety equipment use (S. Systems)	.18
D1.16. Quality of training (Training)	.21			D3.11. Team members care to other members compliance (S. Systems)	.16
D1.17. Power given to safety officers (S. Systems)	.14			D3.12. Team members safety care when a delay in production schedule occurs (Values)	.14

Table 2.10

Confirmatory Factor Analysis for single and multilevel model - Organizational Safety Climate Scale

Model	Step 1 Total	Step 3 Within	Step 4 Between	Step 4 Between	Step 5 Multilevel
Model description	One second order factor and four first order factors (12 items)	One second order factor and four first order factors (12 items)	One second order factor and four first order factors (12 items)	One factor model (12 items)	One second order factor and four first order factors (12 items)
χ^2	378.05	388.02	17148.16	18627.69	440.8
df	50	51	51	54	106
p-value χ^2	.000	.000	.000	.000	.000
NNFI	.940	.918	.458	.40	.916
CFI	.954	.936	.548	.509	.932
RMSEA (C.I)	.080 (.073 – .088)	.086 (.078 – .094)	.59 (.59 – .60)	.62 (.61 – .63)	.059
SRMR	.033	.042	.046	.041	.040w .078b

Table 2.11

Confirmatory Factor Analysis for single and multilevel model - Supervisor Safety Climate Scale

Model	Step 1 Total	Step 3 Within	Step 4 Between	Step 4 Between	Step 5 Multilevel
Model description	Two factor model (10 items)	Two factor model (10 items)	Two factor model (10 items)	One second order factor and two first order factors (10 items)	Two factors model (within). One second order factor and two first order factors (between) (10 items)
χ^2	307.83	207.95	12647.06	12664.7	244.79
df	34	34	34	35	70
p-value χ^2	.000	.000	.000	.000	.000
NNFI	.964	.968	.504	.514	.966
CFI	.972	.957	.622	.622	.975
RMSEA (C.I)	.085 (.076 – .093)	.084 (.076 – .096)	.719 (.71 – .73)	.709 (.70 – .72)	.059
SRMR	.026	.03	.028	.028	.031w .032b

Table 2.12
Confirmatory Factor Analysis for single and multilevel model - Coworkers Safety Climate Scale

Model	Step 1 Total	Step 3 Within	Step 4 Between	Step 5 Multilevel
Model description	One second order factor and four first order factors (12 items)	One second order factor and four first order factors (12 items)	One second order factor and four first order factors (12 items)	One second order factor and four first order factors (within). Four factors model (between) (12 items)
χ^2	480.82	307	20152.39	244.79
df	50	51	54	70
p-value χ^2	.000	.000	.000	.000
NNFI	.95	.95	.430	.966
CFI	.96	.96	.533	.975
RMSEA (C.I)	.086 (.079 – .094)	.077 (.068 – .085)	.660 (.65 – .67)	.059
SRMR	.031	.04	3533	.031w .032b

Table 2.13

Multilevel Confirmatory Factor Analysis in the calibration sample for OSC scale: Fit indexes for five models

Model	Mod 2	Mod 5
Model description	One second ord model with four factor (within&between)	One second ord model with four factor (within). One factor model (between)
χ^2	440.8	477.91
df	106	105
p-value χ^2	.000000	.000000
$\Delta\chi^2$	45.3	40.1
df $\Delta\chi^2$	9	3
p-value $\Delta\chi^2$	.000000	.000000
NNFI	.92	.91
CFI	.93	.92
RMSEA	.059	.063
SRMR w.	.04	.042
SRMR b.	.078	.054
BIC	36560.58	36576
AIC	384.8	421.9
ECVI	.43	.47

Table 2.14

OSC scale - Standardized parameters estimates for Model 2 (One second order model with four factor (within&between)) and for Model 5 (One second order model with four factor (within) and 1 factor model (between))

	Model 2								Model 5				
	Within level (individuals)				Between level (work-groups)				Within level (individuals)				Between level (work-groups)
Item	Com.	Train.	Syst.	Val.	Com.	Train.	Syst.	Val.	Com.	Train.	Syst.	Val.	OSC
D1.02	.64				.97				.65				.89
D1.05	.80				1*				.80				.98
D1.12	.69				.99				.69				.97
D1.03		.67				1*				.67			.96
D1.09		.72				.98				.72			.94
D1.16		.75				.97				.75			.90
D1.08			.78				.98				.78		.96
D1.11			.64				.99				.65		.98
D1.17			.65				1				.66		.99
D1.07				.74				.98				.75	.96
D1.10				.69				.99				.70	.96
D1.14				.75				.97				.76	.93

* In Model 2 residual variance of items D1.03 and D1.05 were fixed at .0001.

Table 2.15

Multilevel Confirmatory Factor Analysis in the calibration sample for SSC scale: Fit indexes for five models

Model	Mod 1	Mod 2	Mod 3	Mod 4
Model description	Two factor model with covariations among factors (within&between)	One second-order factor and two first- order factors (within&between)	Two factor model (within). One second-order factor and two first- order factors model (between)	One second-order factor and two first- order factors model (within). Two factor model (between)
χ^2	246.2	257.89	244.79	260.2
df	69	71	70	70
p-value χ^2	.000000	.000000	.000000	.000000
$\Delta\chi^2$	246.2	11.69	13.1	15.41
df $\Delta\chi^2$	-14	2	1	0
p-value $\Delta\chi^2$	.000000	.002894	.000295	-
NNFI	.96	.95	.96	.95
CFI	.97	.96	.97	.96
RMSEA	.06	.060	.059	.062
SRMR w.	.031	.049	.031	.049
SRMR b.	.030	.032	.032	.032
BIC	23278.99	23280,13	23273.17	23286.32
AIC	218.2	225.89	230.2	230.2
ECVI	.304	.315	.300	.321

*In the case of Model 1, $\Delta\chi^2$ refers to the comparison between Model 1 and the Null Model.

Table 2.16
SSC scale - Standardized parameters estimates for Model 1 (One second order model with two factor (within&between)) and for Model 3 (Two factor model (within) and one second order factor with two first-order factor (between)

	Model 1				Model 3			
	Within level (individuals)		Between level (work-groups)		Within level (individuals)		Between level (work-groups)	
Item	Val.-Sys.	Coach. - Comm.	Val.-Sys.	Coach. - Comm.	Val.-Sys.	Coach. - Comm.	Val.-Sys.	Coach. - Comm.
D2.01	.706		.997		.765		.997	
D2.09	.837		.997		.852		.997	
D2.10	.861		1.000		.872		1.000	
D2.06	.719		.995		.741		.995	
D2.08	.718		.996		.738		.997	
D2.11	.830		.998		.845		.998	
D2.04		.868		.973		.878		.973
D2.02		.857		1.000		.867		1.000*
D2.03		.824		.990		.838		.990
D2.05		.713		.835		.731		.833

* In Model 1 and in Model 3 residual variance of items D2.02 was fixed at .0001.

Table 2.17

Multilevel Confirmatory Factor Analysis in the calibration sample for CSC scale: Fit indexes for five models

Model	Mod 2	Mod 3	Mod 4
Model description	One second-order factor and four first-order factors (within&between)	Four factor model (within). One second-order factor and four first- order factors model (between)	One second-order factor and four first-order factors model (within). Four factor model (between)
χ^2	365.99	344.86	336.72
df	106	104	104
p-value χ^2	.000000	.000000	.000000
$\Delta\chi^2$	55.7	21.13	8.14
df $\Delta\chi^2$	8	2	0
p-value $\Delta\chi^2$	.000000	.000026	-
NNFI	.94	.94	.95
CFI	.95	.96	.96
RMSEA	.054	.053	.051
SRMR w.	.031	.031	.035
SRMR b.	.090	.081	.056
BIC	33310.06	33313.47	33288.83
AIC	309.99	318.86	284.72
ECVI	.363	.373	.333

*In the case of Model 1, $\Delta\chi^2$ refers to the comparison between Model 1 and the Null Model.

Table 2.18

CSC scale - Standardized parameters estimates for Model 4 (One second order model with four factor (within) and four factor model (between)

	Within level (individuals)				Between level (work-groups)			
Item	Com.	Ment.	Syst.	Val.	Com.	Ment.	Syst.	Val.
D3.05	.729				1.000*			
D3.06	.835				1.000*			
D3.09	.660				.997			
D3.03		.816				.987		
D3.01		.775				.987		
D3.04		.799				.960		
D3.10			.813				.983	
D3.11			.870				1.000*	
D3.07			.799				.936	
D3.02				.824				.982
D3.08				.745				1.000*
D3.12				.684				.999

* Residual variance of items D3.05, D3.06, D3.08 and D3.11 were fixed at .0001.

Table 2.19

The final version of the three Safety Climate scales, with the short description of items and the specification of the dimensions

OSC scale

factor	items
Safety communication	Space to discuss in meeting
	Management attention to workers ideas to improve safety
	Workers consultation on safety issues
Safety training	Information supply on safety issues
	Investments on safety training
	Quality of safety training
Safety values	Management safety care in production schedule
	Management safety care in moving-promoting people
	Management safety care on a delay in production schedule
Safety systems	Management effort on safety improvement
	Management reaction to solve safety hazard
	Power given to safety officers

SSC scale

factor	items
Supervisor's reaction	Supervisor safety rules care when a delay in production schedule occurs
	Supervisor care to provide workers needed safety equipment
	Supervisor care to the use of safety equipment
	Supervisor safety rules care when workers are tired
Supervisor's effort	Supervisor discusses with workers on safety improvement
	Supervisor care to workers safety awareness
	Supervisor coaching about safety care
	Supervisor praise to very careful safety behaviours
	Supervisor care to all safety rules
	Supervisor control the compliance of all the workers

CSC scale

factor	items
Safety communication	Team members speaking on safety on the week
	Team members discussing about incident prevention
	Team members discussion about safety hazard
Safety mentoring	Team members emphasis to peers on safety care when under pressure
	Team members care of peers safety awareness
	Team members mentoring to peers about working safely
Safety values	Team members safety care at the shift end
	Team members safety care when tired
	Team members safety care when a delay in production schedule occurs
Safety systems	Team members care to others workers safety equipment
	Team members remind safety equipment use
	Team members care to other members compliance

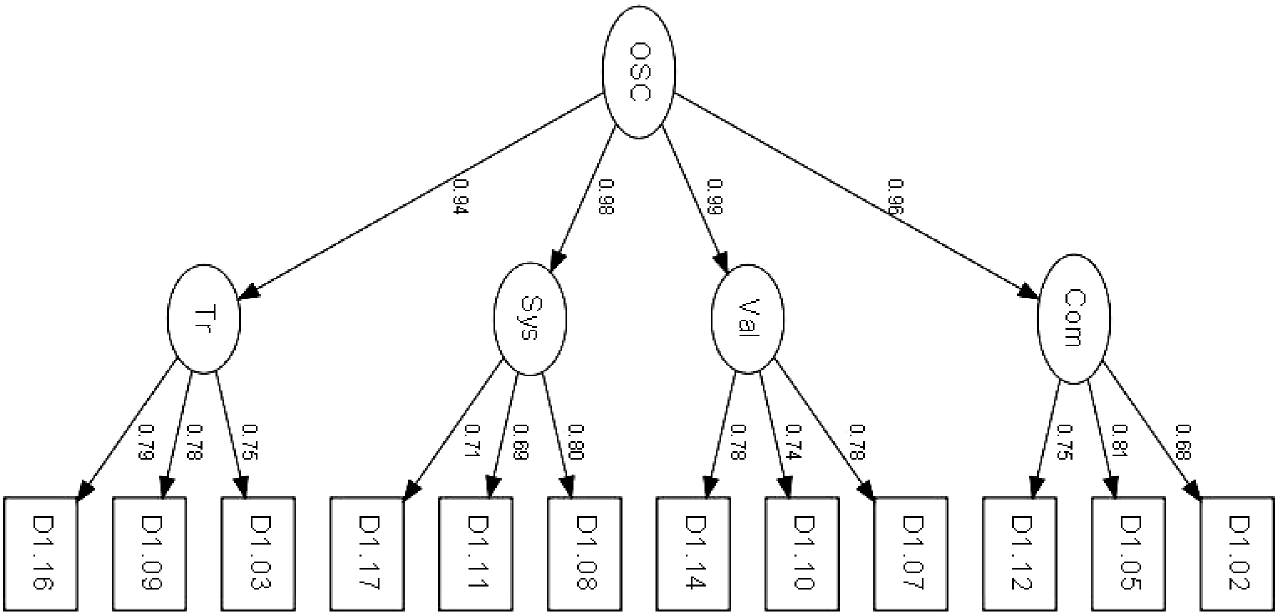

Figure 2.1. Path diagram of Organizational Safety Climate Scale (Model 6) with estimates in standardized solution.

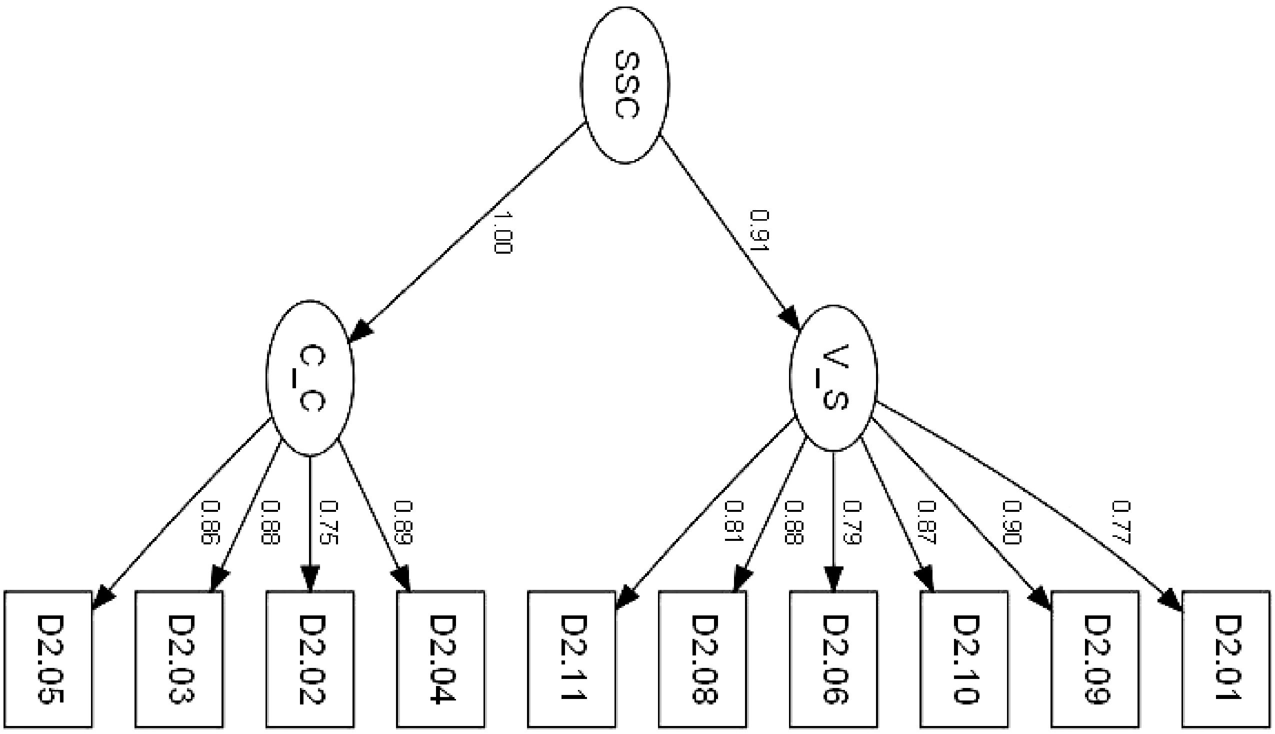

Figure 2.2. Path diagram of the Supervisor's Safety Climate Scale (Model 7) with estimates in standardized solution.

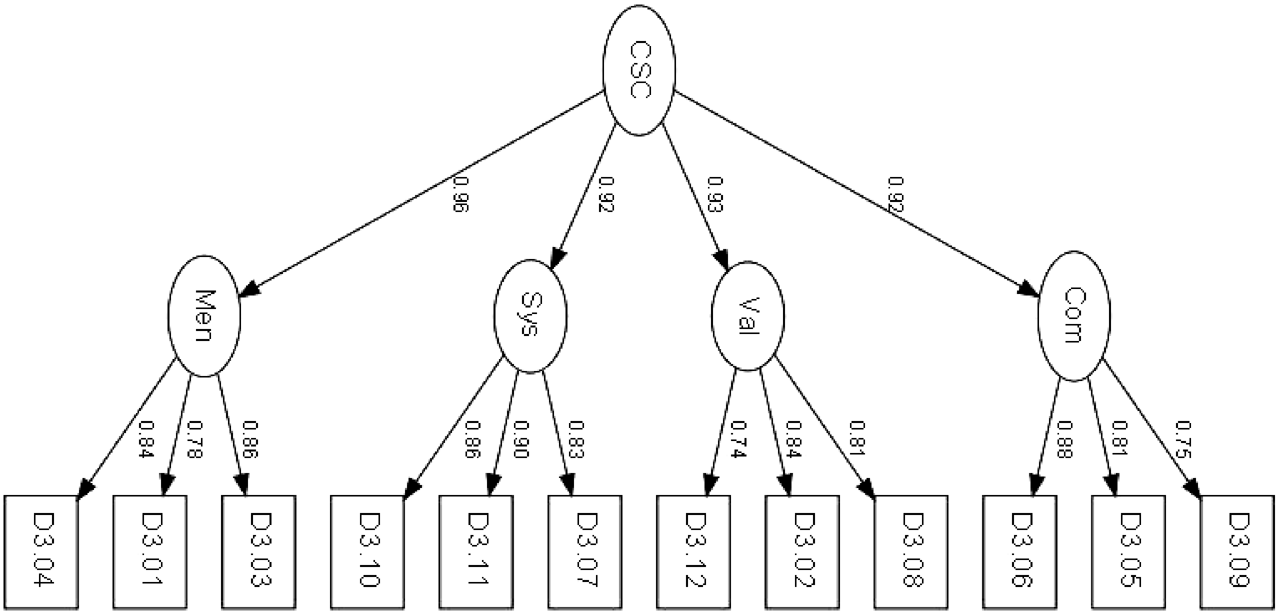

Figure 2.3. Path diagram of the Co-workers' Safety Climate Scale (Model 4) with estimates in standardized solution.

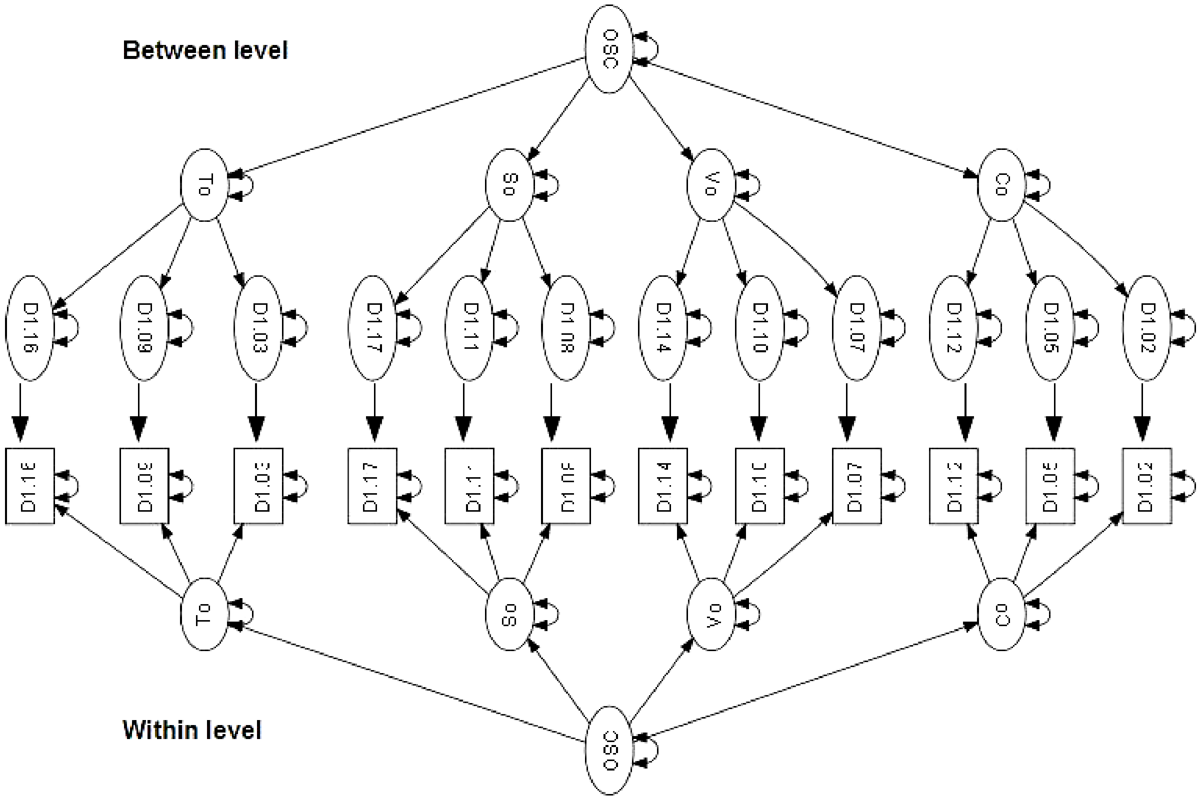

Figure 2.4. Path diagram of the multilevel model for the Organizational Safety Climate Scale (Model 2)

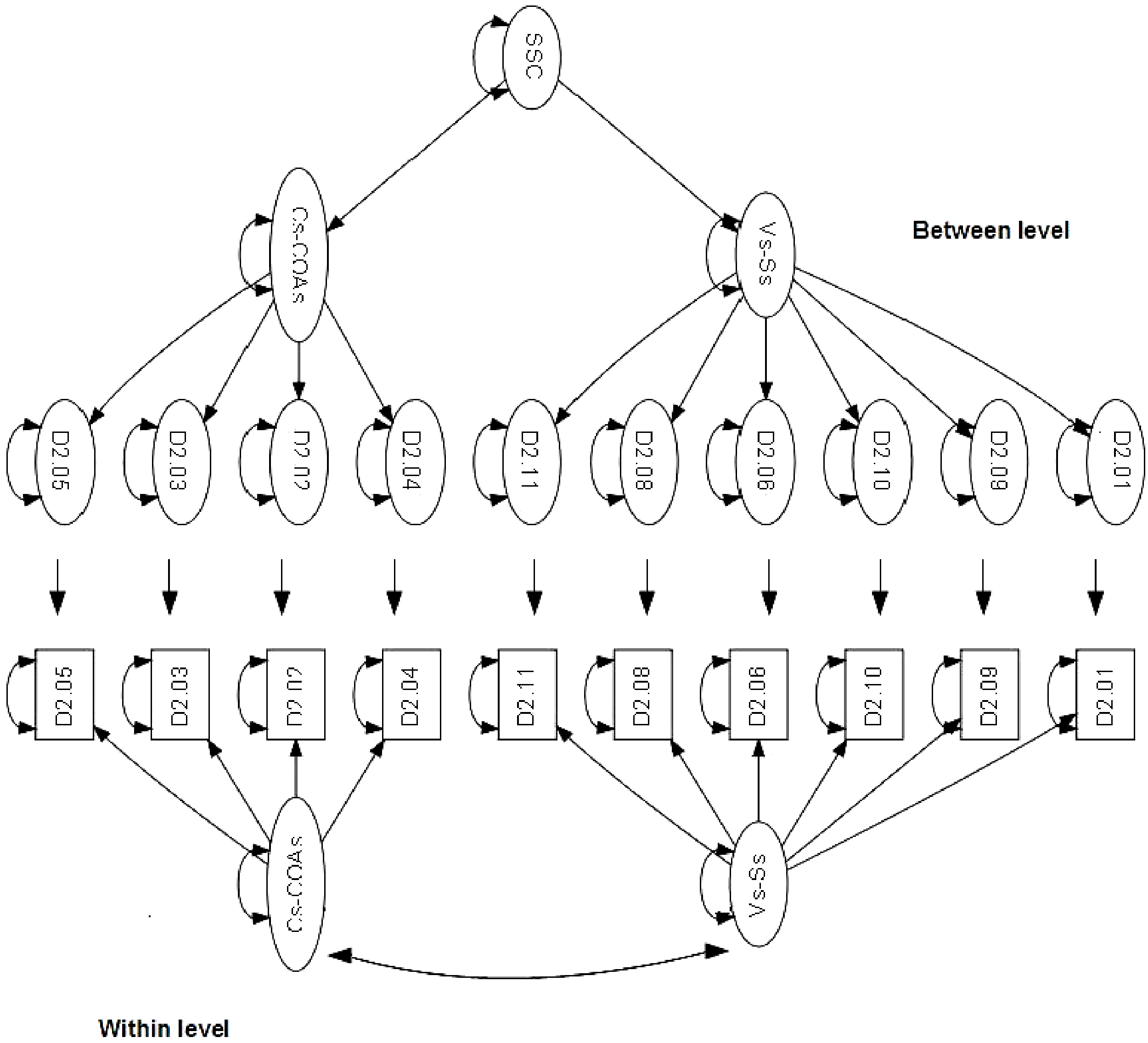

Figure 2.5. Path diagram of the multilevel model for the Supervisor's Safety Climate Scale (Model 3)

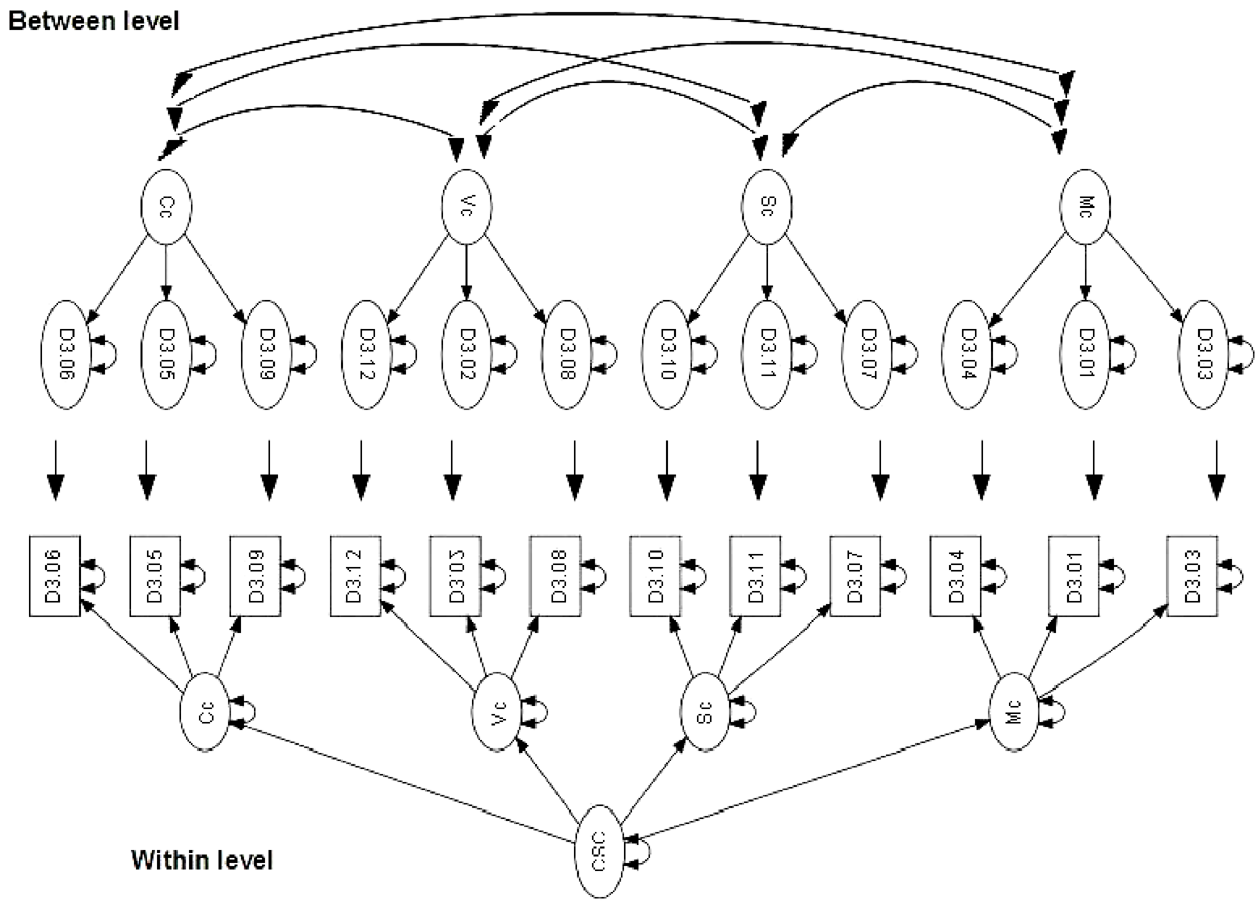

Figure 2.6. Path diagram of the multilevel model for the Co-workers' Safety Climate Scale (Model 4)

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Capitolo 3

The relationship between safety climate and safety performance by the safety agents' point of view

Abstract

The aim of this study is to investigate the relationship between safety climate and safety performance, considering safety climate as an integrated system of many climates. Firstly, the assessment of an integrated system of safety climates with multilevel structural equation modelling was performed. Then, we assessed the relationships between the integrated system of safety climate and safety behaviours using the same technique. From the literature, the importance to study safety climate in a multilevel perspective by a theoretical and methodological point of view is known. To analyse safety climate as an integrated system of safety climates – a system in which safety climate is defined for each safety agent in an organization, not only top management and supervisors, but also co-workers – permit to study more deeply the interactions of different climates at different organizationals levels, and the relationships between these climates and safety behaviours. We used a two-level design which considered the individual level and the work-group level. Data collection involved 991 blue-collars, belonging to 91 work groups, from 5 Italian manufacturing companies. The research evidenced the importance of considering at group level not only climate referred to supervisor, but also climate referred to co-workers. Furthermore, analyses revealed that co-workers' safety climate had a stronger influence on safety behaviours, and in particular on safety participation, than supervisor's safety climate, at individual level as well at group level.

Introduction

Safety climate has been one of the most frequently studied antecedents of safety performance since nineties. Safety climate is usually defined as the shared perceptions of the employees on policies, procedures, and practices relating to safety. It can be investigated at two hierarchical levels: group level, and organizational level. At the group level, safety climate usually refers to the role of supervisor (e.g. Zohar, 2000; Zohar & Luria, 2005; Wallace, & Chen, 2006, Melià & Sesè, 2007) and not to co-workers. The role of co-workers has been studied regarding different aspects: co-workers' support (e.g. Chiaburu & Harrison, 2008; Burt, Sepie & McFadden, 2008); co-workers' practices (e.g. Melià & Becerril, 2006; Melià, Mearns, Silva & Lima, 2008; Jiang, Lu, Li & Li, 2009), social norms (e.g. Fugas, Silva & Melià, 2009; Kath, 2010); co-workers' interaction (e.g. Cavazza & Serpe, 2009; Zohar & Tenne-Gazit, 2008; Zohar, 2010a); and also regarding a more generalized content as co-worker safety (e.g. Gyekyes & Salminen, 2009; Morrow, McGonagle, Dove-Steinkampa, Walker, Marmeta & Barnes-Farrella, 2010). Items about co-workers are sometimes used as a dimension of a whole safety climate scale. Melià et al. (2008) identify co-workers as a safety agent as important as the organization and the supervisor and show in their study that organizational safety response and supervisor's safety response significantly and positively predict co-workers' safety response. The aim of the present study was to explore a structure of integrated safety climates by the point of view of the safety agents and hence to analyse the mediating role of co-workers' safety climate between organizational and supervisor's safety climate and safety performance.

Safety climate

Safety climate has been recently re-defined as a multilevel construct (Zohar, 2000;

Zohar & Luria, 2005; Zohar, 2008, 2010b; Glendon, 2008; Melià et al., 2008). Many scholars underlined that organizational processes take place simultaneously at several levels, and that processes at different levels are linked in some way (e.g. Kozlowski & Klein, 2000; Shannon & Norman, 2008). Hence processes that take place at one hierarchical level have an influence on other levels. Concerning safety climate, this implies that climates have different meanings at different organizational levels, as well as cross-level relationships.

Zohar & Luria (2005) suggested that the core meaning of safety climate relates to socially construed indications of desired role behaviour, coming simultaneously from policy and procedural actions of top management and from practices of the supervisors.

One important assumption to distinguish safety climate at organizational and group level is employees capability to distinguish between procedures defined by top management and those executed by supervisors and between supervisor's behaviours backed by company management and supervisor's behaviours decided by own self. Therefore, at the organizational level, safety climate regards perceptions of the workers on polices and procedures defined by top management, while, at the group level, safety climate regards perceptions of the workers on how the supervisors implement these polices and procedures by transforming them into daily practices.

The authors showed that the effect of organizational safety climate on safety behaviours in work groups is completely mediated by group (supervisor) safety climate (see Figure 1).

On the same multilevel perspective, Melià et al. (2008) studied safety climate from the point of view of the agents performing safety at work. In particular, they analysed the psychosocial chain of safety influences among the safety responses and the perceived probability of accidents. One important focus of the research by Melià et al. is the emphasis on safety climate as a diagnostic tool to explore specific issues that should be considered important to improve safety at work. Given this premise, they identified four main agents (organization, supervisors, co-workers and workers) which are responsible for every safety issue inside the organization (e.g. safety process, action, omission, responsibility). Taking these agents into account, the authors studied five main safety climate variables: organizational safety response, supervisors' safety response, co-workers' safety response, worker safety response and perceived risk of accidents. Melià et al. studied the relationships between these safety climate variables on four different samples (see Figure 2).

In the four samples supervisors' safety response was significantly predicted by organizational safety response. Co-workers' safety response was significantly predicted by organizational safety response and by supervisor's safety response in all the samples. Worker safety response was positive and significantly predicted by co-workers' safety response and also by organizational safety response in the four samples but it was positive and significantly predicted by supervisor's safety response only in two samples.

The idea of the present study is to compare Zohar & Luria (2005), and Melià et al. (2008) approaches exploring the role of co-workers as safety climate agent at group level and as mediating role between organization and supervisor's safety climate, and workers safety behaviours. Melià et al. (2008) identified co-workers as a safety agent important as the organization and the supervisor and showed in their study that organizational safety climate and supervisor's safety climate positively and significantly predict co-worker safety climate. Chiaburu & Harrison (2008) in their research showed that co-worker support and antagonism have a unique effect on employees' outcomes beyond that of leader influences and that co-workers' support has a strong positive relationship with task performance. Melià et al. (2008) gave empirical evidence of the relationships between organizational, supervisorìs and co-workers' safety response, and workers safety behaviours. On the basis of these empirical evidences, a conceptual multilevel model of safety climates framework associated to safety outcomes was proposed (see Figure 3). The model specifies effects of organizational, supervisor's and co-workers' safety climates at individual level (the within-group model, below the dotted line in Figure 3) and at group level (the between-group model, above the dotted line in Figure 3). At the individual level, all the climate constructs are obviously considered as psychological climates.

The following hypotheses describe the model in detail.

H1: Organizational safety climate positively and significantly predicts co-workers' safety climate and supervisor's safety climate.

H2: supervisor's safety climate mediates the relationship between organizational safety climate and co-workers' safety climate.

H3a : co-workers' safety climate mediates the relationship between organizational safety climate and workers safety behaviours.

H3b : co-workers' safety climate mediates the relationship between supervisor's safety climate and workers' safety behaviours.

H4: for the prediction of safety behaviours, a model considering not only the role of organizational safety climate and supervisor's safety climate in predicting workers' safety behaviours, but also the mediating role of co-workers' safety climate, is more explicative than a model that does not include the co-workers' role.

Safety performance

Work behaviours, which are relevant to safety, can be considered in the same way as other work behaviours constituting work performance. Borman & Motowidlo (1993) proposed two main components of work performance: task performance and contextual performance.

Task performance is defined as “ the activities that are formally recognized as part of their jobs, activities that contribute to the organization's technical core either directly or indirectly” (p. 73). Contextual performance “supports the organizational, social and psychological environment in which the technical core must function” (p. 73). Griffin & Neal (2000) applied the same two categories to differentiate safety behaviours in the workplace. Task performance becomes safety compliance, which refers to activities as obeying safety regulations, following the correct procedures and using appropriate equipments. Contextual performance becomes safety participation which refers to behaviours that do not directly increase workplace safety, but contribute to develop an environment that support safety.

Griffin & Neal (2000) found a stronger relationship between organizational safety climate and safety participation than between organizational safety climate and safety compliance. Similarly Christian et al. (2009) found a stronger relationship between group safety climate and safety participation than between group safety climate and safety compliance.

These arguments suggest the following hypothesis:

H5: A model predicting safety participation is more explicative than the same model predicting safety compliance

Method

Participants

The present study was supported by Istituto Nazionale per l'Assicurazione contro gli

Infortuni sul Lavoro (INAIL) of Vicenza and by INAIL (the OSH national institution of Italy[11]) of the Veneto Region, and by the three main Italian federations of metal workers (Federazione Italiana Metalmeccanici (FIM) Federazione Impiegati e Operai Metallurgici (FIOM), Unione Italiana Lavoratori Metalmeccanici (UILM)). The study regarded the metal-mechanic sector companies involving the main branches of metal-mechanic work (fabrication of machinery, electrical devices and work vehicles), choosing the ones most represented in the territories wehere the research study was performed.

Regarding dimension, we chose to collect data in small, middle, and large size organizations on the basis of the number of the employees, considering three level sizes: small (from 0 to 50 employees); medium (from 50 to 200); large (200 and beyond).

From the geographical point of view, attention was focused on a specific area, such as the region of Veneto, a high-developed industrial zone with a high rate of accidents on workplace, particularly in the metal-mechanic sector, which is one of the most relevant industrial sector of this region.

Five companies (one small, two medium and two large companies) agreed to participate to the study. A mean percentage of 82,6% of blue-collars of the companies was involved.

A two-level design was used, considering the individual level and the work-group level. All data was collected at individual level, and data collection involved 991 blue-collars. To study the group level, for each participant the work-group was registered, and the total number of work-groups in the five companies was 91. Table 1 shows the characteristics of the five companies.

Considering the whole sample, 86% of the participants were males; 75% were Italian

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[11] INAIL is an Italian institution pursuing several objectives: the reduction of accidents at work, the insurance of workers involved in risky activities; the re-integration in the labour market and in social life of work accident victims.

workers; 82% had an educational level from 5 to 13 years of school; only 5% of the participants had been working in the company for less than 1 year, and 70% had been working worked for the same company for 5 years or more; 66% of participants had a permanent contract. Table 2 shows the characteristics of the participants.

Measures

In the previous chapter, we described the the development of the safety climate measures (Organizational safety climate, Supervisor's safety climate and Co-workers' safety climate) that we used in the present work.

Organizational safety climate (OSC) is measured with a 12-item scale in which the target of the safety climate judgement given by the worker is the entire organization. This scale is the result of a validation process merging ten items from the Multilevel Safety Climate Scale of Zohar & Luria (2005) with two items from the Safety Climate Scale of Griffin & Neal (2000, personal communication), as explained in the previous chapter. Items are accompanied by a 7-point rating scale, ranging from 1 (never) to 7 (always).

Each item of OSC scale is connected to one of the four domains identified by Griffin & Neal (2000, personal communication): Management values, Safety systems, Safety communication, and Safety training (see table 2). Management values regard the degree to which managers valued safety in the workplace, represented by items such as *"Top management considers safety when setting production speed and sc*hedules". Safety systems refer to the effectiveness of safety systems in the organization, for example *"Top management provides all the equipment needed to do the job safely".* Safety communication is about how safety issues are communicated, for example *"Top management listens carefully to workers'* *ideas about improving safety".* Safety training refers to the quality and quantity of the employees' s opportunities to be trained, including items such as *"Employees receive comprehensive training in workplace health and safety issues".* Since the previous chapter was focused on the validation of the three safety climate scales, for each safety climate scales only alpha reliability was reported. Alpha reliability of this scale was .93. Furthermore Construct Reliability (CR) and Average Variance Extracted (AVE) for each first-order factor were calculated: values (CR .80; AVE .58), safety system (CR .77; AVE .53), safety communication (CR .78; AVE .54) and training (CR .80; AVE .58). All the values were above the fixed threshold (.70 for construct reliability and .50 for variance extracted as suggested by Hair, Anderson, Tatham & Black, 1998).

Supervisor's safety climate (SSC) was assessed by a 10- item scale in which the workers had to judge the real importance given to safety by their direct supervisor in the work-group. This is an adjusted version of the Group-level Safety Climate scale by Zohar & Luria (2005). Items are accompanied by a 7-point rating scale, commensurate with the organizational level scale. Each item of SSC scale refers to two domains identified as supervisor's reaction to the workers' safety behaviours (for example *"My direct supervisor is strict about working safely when we are tired or stressed"*) and supervisor's own safety behaviour and effort to improve safety (for example "*My direct supervisor uses explanations (not just compliance) to get us to act safely")* (Melià & Sesé, 2007; Zohar, 2000) (see table 3). Such as for the OSC scale, psychometric properties of SSC scale were assessed with multilevel confirmatory factor analysis in the previous chapter. Alpha reliability of this scale was .95. Furthermore CR and AVE for each first-order factor were calculated: first factor (CR .93; AVE .69); second factor (CR .91; AVE .72).

Co-workers' safety climate (CSC) is measured with a 12-item scale in which the target of the safety climate judgement given by the workers is if safety is a real priority of their colleagues. Such as the previous safety climate scales, responses were given on a 7-point Likert scale, from 1 = "never" to 7 = "always". Items of the CSC Scale were derived from the adjustment to co-workers of the group level safety climate scale of Zohar & Luria (2005) and comparing the resulted items with items content of co-workers' scales by co-workers' safety climate literature (e.g. Fugas, Silva and Melià, 2009; Singer et al., 2007; Melià, 1998; Melià & Becerril, 2006; Melià et al, 2008; Jiang et al., 2009). Every item of CSC scale is connected to one of the four domains identified by Griffin & Neal (2000, personal communication): co-workers' values, Safety systems, Safety communication, and Safety Mentoring. The Griffin & Neal's dimension of 'Training' was changed into 'Mentoring', which was more suitable to the co-workers' role. This dimension refers to co-workers' activities oriented to support colleagues to improve their safety behaviour for example giving them suggestions and calling attention to safety (Ensher, Thomas, & Murphy, 2001). Co-workers' values concern the degree to which co-workers valued safety in the workplace, represented by items such as *"My team members are careful about working safely also when we are tired or stressed."*. Safety systems refer to the attention about safety systems by co-workers, for example *"My team members are careful that the other members receive all the equipment needed to do the job safely."*. Safety communication is about the way in which safety issues are discussed in the team work, for example *"My team members talk about safety issues throughout the work week*". An example of item of Mentoring domain in the CSC scale is "*If it is necessary, my team members use explanations to get other team members to act safely*". Such as for the previous scales, psychometric properties of the scale of the individual perception items are assessed with multilevel confirmatory factor analysis. Alpha reliability of this scale was .95. Furthermore CR and AVE for each first-order factor were calculated: values (CR .84; AVE .63), safety system (CR .90; AVE .75), safety communication (CR .87; AVE .69) and Mentoring (CR .87; AVE . 69).

Safety performance is measured with a 8-item scale which refers to workers safety behaviours. The scale is an adjusted version of Griffin & Neal scale about safety behaviour (2000, personal communication). Two components of safety performance are measured: safety compliance (4 items) and safety participation (4 items). Safety compliance is assessed by four items asking about individual performance of safety compliance (for example "*I use all the necessary safety equipment to do my job*"). Safety participation is assessed by four items about participation that support safety in the workplace, but do not necessarily involve performance related to safety (for example "*I put in extra effort to improve the safety of the workplace*"). A model with a second-order factor (safety behaviour) and two first-order factors (Safety Compliance and Safety Participation) was estimated. Psychometric properties of the scale are assessed with confirmatory factor analysis. Also in this case the estimated model provided a good fit indices, $\chi2_{(18;\ N\ =\ 964)} = 47.38$, $p < .001$; TLI = .98, CFI = .99; SRMR = .023. Alpha reliability of this scale was .84. Furthermore CR and AVE for each first-order factor were calculated: Compliance (CR .83; AVE .54) and Participation (CR .73; AVE .40).

Other questions in the questionnaire

Socio-demographic informations were collected, regarding gender, age, educational level, nationality, length of employment in the company, kind of job-contract, department, work shift at the moment of the survey.

Procedures

Few days before administering the questionnaire, either the top management organized an *ad hoc* meeting with unions, the Safety Commission and the safety officer or a trade-union meeting was held and workers were told that they were part of a larger sample of workers involved in a research supported by INAIL, and received information about the research program. Participants were informed that the questionnaire was anonymous, and all data were collected and conserved by the research group. They were also ensured that only aggregate results would be given to the management of the company.

All participants answered the questionnaire during working hours, at the end or at the beginning of their work shift, and were asked to answer as sincerely as possible. They were told that items concerned with their perception of organizational management, direct supervisor, and work-group co-workers about safety at works; they were told that, in case they found difficult to answer to an item, due to ignorance of something regarding, for instance, organizational policy, they should choose the answer which was closest to the their perception. At the end of the questionnaire participants were asked to answer questions about some socio-demographic data. Along with the Italian questionnaire, English and a French translations were also provided for foreign workers. Researchers were available to help participants, if necessary. The duration of the the procedure was about 20 minutes.

Data analysis

To model relations among variables at multiple levels, data were analysed with multilevel structural equation modeling (ML-SEM) with full maximum likelihood estimation in M*plus* 5.2 (Muthén & Muthén, 1998–2008). The present study used the example M*plus* syntax created by Preacher, Zyphur, and Zhang (2010) as a starting point for developing the syntax of multilevel models. In ML-SEM the variability in variables is decomposed into two latent components, a within-group (i.e. variability at individual level) component, and a between-group (i.e. variability at group level) component (Muthén & Asparouhov, 2009).

ML-SEM permits to model the relationships among these variance components within each level through the specification of measurement and structural models. At the individual level variables can be specified as having intercepts (and random slopes) that vary across groups. At the group level the random intercepts are modelled as latent variables. In the present study, no random slopes were specified because the complexity of the model and the limited number of work groups not permitted to study cross-level interactions. However, random intercepts were specified for safety climate indicators (organizational, supervisor's, and co-workers' safety climate) and for safety behaviours indicators (global safety behaviours, safety compliance and safety participation), (see Figure 3). Furthermore, ML-SEM provides a more precise estimate of indirect effects in models with variables at multiple levels of analysis because of the manner in which variance is decomposed into two components, hence enabling to avoid problems of merging individual level effect with group level effect (Preacher et al., 2010; Zhang, Zyphur, & Preacher, 2009).

The present study followed several steps to do ML-SEM analyses referring to Preacher et al. (2010) and Muthén (1994) procedures. Some preliminary operations were carried out. Before conducting multilevel ML-SEM analyses.

The first step regards between-group variability to support ML-SEM. First, the composition of work group was analysed. Only groups composed of workers within the same department, working in the same shift and with the same supervisor were selected. Subsequently, the size of each group was analysed, due to the fact/assumption that shared perceptions about climate need the presence of a group. Climate scholars[12] usually indicate as minimum size of a group three or four member: therefore groups with less than 4 members were eliminated from the sample. The variability between groups on each variable was examined by computing the intraclass correlation (ICC) for each variable of the three climate scales (OSC, SSC, and CSC). Muthen (1994) suggested to estimate a unique type of ICC to determine potential group influence. Muthen's ICC index is conceptually similar to ICC(1). The difference between the two indexes is that Muthen's ICC is obtained by random effects ANOVA, while ICC(1) is obtained by fixed effects ANOVA. ICC ranges in value from 0 to 1. If values are close to zero (e.g. .05) the multilevel modelling will be meaningless (Dyer, Hanges & Hall, 2005).

Homogeneity of climate perceptions was also assessed with the median value of $r_{wg(j)}$ (Bliese, 2000) for each work group (or unit) using a uniform null distribution for the safety climate indicators. This method was used to ensure that a sufficient level of within-group agreement would be present in the variables for which we had substantive interest at the group level. Agreement was evaluated using LeBreton and Senter’s (2008) revised standards for interpreting interrater agreement estimates. For the three group-level constructs, organizational, supervisor's and co-workers' safety climates, it was found a level of agreement to support their inclusion (i.e., median values greater than or equal to .70; LeBreton & Senter, 2008). The agreement was not calculated for safety behaviours indicators because the interest in the variables was at the individual level.

In the second step the investigation of a properly specified within-group model was performed. Since the measurement model was investigated in the previous chapter, in this step

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[12] Personal communication with Dov Zohar, expert of safety climate. Dov Zohar is professor at the William Davidson Faculty of Industrial Engineering and Management Technion - Israel Institute of Technology.

the attention was focused especially on the specification of the within-group structural model. Preacher et al. (2010) suggest two ways to fit the within-group model. The first one requires to group mean center all observed variables and then to fit the within-group model as a single level model. The second one involves fitting the full model, allowing the group-level constructs to freely covary. In the present study the second way to fit within-group model was performed.

In the third step, the hypothesized within-group and between-group structural model was analysed. Organizational safety climate at group level was considered as the shared perceptions of work groups on the real importance given to safety by the top management.

After that, Zohar model was fitted with ML-SEM to compare it with the hypothesized model. The aim is to assess the validity of the hypothesis that the addition of co-workers' safety climate as mediator between supervisor's safety climate and safety behaviours entails that more variability of safety behaviours is explained.

Finally the hypothesized model with the focus on the relationship between safety climate constructs and each component of safety performance was explored.

Goodness of fit of the models was evaluated also using the Tucker Lewis Index (TLI; Tucker & Lewis, 1973), the comparative fit index (CFI; Bentler, 1990), the root mean square error of approximation (RMSEA; Hu & Bentler, 1999), the standardized root mean square residual (SRMR). For TLI and CFI a value between .90 and .95 is acceptable, and above .95 is good. RMSEA is a global fit measure based on residuals; good models have an RMSEA of .05 or less. Models whose RMSEA is .10 or more have poor fit. RMSEA of .08 is acceptable (Hu & Bentler, 1999). SRMR indicates the closeness of predicted covariances matrix to the observed one; values of zero indicates perfect fit and a value less than .08 is considered a good fit. This measure tends to be smaller as sample size increases and as the number of parameters in the model increases. Also GFI and AGFI, that are common indexes in many SEM packages, are reported, even if they are affected by sample size and can be large for models that are poorly specified, and the current consensus is not to use these measures (Kenny, 2010 http://davidakenny.net/cm/fit.htm). Values close to .95 reflects a good fit.

Descriptive statistics and aggregation analysis

At first a specific analysis of the missing values frequency for each variable was conducted on the sample. All cases with more than 5% of missing values were removed (Chemolli & Pasini, 2007).

To be sure that this choice did not invalidate our sample, examination of missing values considering the socio-demographic characteristics was made, using chi square test. Twenty-eight cases were removed (3% of the whole sample), because of missing values over the threshold of 5%. The analysis of the missing values showed that they were equally distributed among the various socio-demographic characteristics of the sample.

Then work groups composition and homogeneity of climate perceptions were analysed and work groups which not satisfied conditions were eliminated. After that, the sample size was composed of 895 cases and 64 work groups. In Table 3 the results about variability between groups to support multilevel analyses are reported. Significant between-group variance was observed for all variables with ICCs ranging from .11 (safety communication between co-workers) to .26 (supervisor's reaction to workers safety behaviours). These values underlined the importance of conducting an ML-SEM because of the affection of group membership to individual level observation. Furthermore, the median values of $r_{wg(j)}$ across groups were analysed. The median values for organizational safety climate, supervisor's safety climate and co-workers' safety climate were respectively .87 (OSC), .70 (SSC), and .85 (CSC), indicating a good homogeneity of climates perceptions inside groups.

At the end of this process, for each indicator mean and standard deviation were computed, and indicators were also checked for normal distribution, computing skewness and kurtosis and considering normally distributed all the items with values into the range -1/+1. Responses were approximately normally distributed, with skewness ranging from -.61 to .58 and kurtosis values ranging from -1.17 to .62. The unique value out of the range was the kurtosis value of supervisor's reactions to workers behaviours (-1.17), but it was not considered a problem since mean kurtosis (|M| = .74) was inferior to |1| (Muthen & Kaplan, 1985).

In Table 4 means, standard deviations, and bivariate correlations for the measures used in the present study are reported. From a review of the means it seemed that overall respondents perceived positive safety climate for all safety agents. After a look at bivariate correlations some interesting informations could be reported. For instance, at the individual level safety compliance resulted more correlated to supervisor's reactions to workers behaviours (.36, $p < .01$) than to other indicators, and safety participation was more correlated to co-workers' safety communication (.43, $p < .01$).

Results

To test the hypothesised multilevel structural model shown in Figure 3 the first operation was to estimate the measurement model. In the measurement model, for each safety climate the climate indicators were loaded onto the psychological climate latent factor in the within-group model. The same structure was defined for safety performance with its two indicators (compliance and participation). In the between-group model the random intercepts for safety climates indicators served as indicators for the group climate latent factor (Muthén & Asparouhov, 2009). All standardized factor loadings were statistically significant and suggest that all items adequately reflected the latent constructs.

The measurement model provided good fit to the data ($\chi2_{(99;\ N\ =\ 895)}$ = 364.62 , p < .001, CFI = .96, RMSEA= .06, $SRMR_{within}$ = .04, $SRMR_{between}$ = .05) permitting to proceed with the estimate of the within-group structural model (see Table 5). This estimate was conducted allowing the constructs freely covary at the group level. The fit indices for the within-group structural model were almost the same of the previous model ($\chi2_{(100;\ N\ =\ 895)}$ = 378.24 , p < .001, CFI = .96, RMSEA= .06, $SRMR_{within}$ = .04, $SRMR_{between}$ = .05); this is not unusual given that a similar number of parameters were estimated.

Then, the ML-SEM model was analysed estimating simultaneously within-group and between-group structural models. The model again showed good fit indices ($\chi2_{(101;\ N\ =\ 895)}$ = 380.83 , p < .001, CFI = .96, RMSEA= .06, $SRMR_{within}$ = .04, $SRMR_{between}$ = .05). The accounted variations in supervisor's safety climate, in co-workers' safety climate, and in safety behaviours were at individual level 63%, 44% and 38% respectively, and at group-level 83%, 91% and 76% respectively.

Finally, an alternative model which included a direct path between organizational safety climate and safety behaviours was estimated. The fit of the alternative model was a little better ($\Delta\chi^2_{(2,\ N\ =\ 895)}$ = 13,85, p < .001) than that of the previous model and the other fit indices were very similar (CFI = .96, RMSEA= .06, SRMRw = .04, SRMRb = . 05. Also AIC and BIC indices were nearly equal (for the first model 30279,41 and 30609,7 respectively and for the second model 30288,96 and 30609,67 respectively). The direct path between organizational safety climate and safety behaviours was statistically significant at individual level (β = .25 p <

.01) but not statistically significant at group level (β = .42 $p > .05$). It is interesting to note that with the insertion of the direct path the relationship between supervisor's safety climate and safety behaviours became not statistically significant (β = .02 $p > .05$), reducing the indirect effect of supervisor's safety climate mediation between organizational safety climate and safety behaviours. On the basis of all these arguments the model with the direct path between organizational safety climate and safety behaviours was retained. This model is presented in Figure 4 along with path estimates.

In support of Hypothesis1, which assumed that organizational safety climate positively and significantly predicts co-workers' safety climate and supervisor's safety climate, at the individual as well as at the group level there was a strong positive relationship between organizational and supervisor's safety climate (β =.79, $p < .001$ at individual level and β =.91, $p < .001$ at group level). The relationship between organizational safety climate and co-workers' safety climate was positive and statistically significant at individual level as well as at group level (β =.14, $p < .05$ at individual level and β =.87, $p < .001$ at group level). It is interesting to note that at group level the relationship between organizational safety climate and co-workers' safety climate was stronger than at individual level. This means that there was a weaker influence between psychological safety climate referred to organization and psychological safety climate related to co-workers than between shared perceptions on organizational safety priorities climate and shared perceptions on co-workers' safety priorities.

Hypothesis 2, which refers to the mediating role of supervisor' safety climate, was supported at the individual level but not supported at the group level. At the individual level, the standardized total indirect effect of organizational safety climate on co-workers' safety climate was positive and statistically significant (.44, $p < .001$, 99% CI = .32, .57). This result, in combination with the presence of direct effect of organizational safety climate on co-workers' safety climate, indicates a partially mediated relationship between the two constructs. At the group level Hypothesis 2 was not supported, underling that the shared perceptions of workers about real importance given to safety by their colleagues were strongly influenced by shared perceptions on real importance given to safety by top management and that this relationship was not mediated by shared perceptions real importance given to safety by supervisor's.

Hypothesis 3a and 3b, which hypothesize the mediating role of co-workers' safety climate in the relationship between organizational safety climate and safety behaviours and, in the relationship between supervisor's safety climate and safety behaviours were supported at individual level. In the first case standardized indirect effect of the mediation of co-workers' safety climate was .25, $p < .001$, 99% CI = .17, .33. The relationship was partially mediated because of the the statistically significant coefficient of the direct path between organizational safety climate and safety behaviours. On the other hand the relationship between supervisor's safety climate and safety behaviours was fully mediated by co-workers' safety climate. The standardized indirect effect was .24, $p < .001$, 99% CI = .14, .34. As for the hypothesis 2 at group level both hypotheses (3a and 3b) were not supported. In this respect it can be noted that at group level the relationships between safety climates and safety behaviours were all statistically not significant. This means that, in the examined sample, the variability between-group of individual safety behaviours was not related to the level of all safety climates. To better understand these results, two models analysing separately the mediating role of supervisor's safety climate (Figure 5) and co-workers' safety climate (Figure 6) in the relationship between organizational safety climate and safety behaviours were used. The fit of the two models were was good (see Table 5) and in both cases the mediating role was supported: co-workers' safety climate fully mediated the relationship between organizational safety climate and safety behaviours at group level (.83, $p < .001$, 99% CI = .62, 1.04), and partially mediated it at within level (.25, $p < .001$, 99% CI = .17, .33); supervisor's safety climate partially mediated the relationship at within level (.21, $p < .001$, 99% CI = .06, .37) and fully mediated it at group level (.76, $p < .001$, 99% CI = .57, .96).

Hypothesis 4 suggested that a model that also considers the mediating role of co-workers' safety climate is more explicative than a model not considering it. Figure 5 shows the estimated model without the mediating role of co-workers' safety climate and Figure 6 shows the estimated model without the mediating role of supervisor's safety climate. It can be seen that at the individual level as at the group level the safety behaviours variability explained from the model which includes co-workers' safety climate was larger than that explained from the model which does not include it (at individual level 40% instead of 31%, and at group level 75% instead of 67%).

To support hypothesis 5, two new models were estimated replacing the latent construct "safety behaviours" with its components (safety compliance and safety participation). The model predicting safety participation accounted for 26% of the within-group variation, while the model predicting safety compliance accounted for 17%. Also at group-level the variation accounted in safety participation is larger than that accounted in safety compliance (81% instead of 77% respectively).

Discussion and future directions

The goals of this study were to explore a structure of integrated safety climates by the point of view of the safety agents, and consequently to explore the mediating role of co-workers' safety climate in the relationships between organizational safety climate and safety behaviours, and between supervisor's safety climate and safety behaviours. To our knowledge, no research has examined, so far, safety climate as an integrated system of specific safety climates maintaining the complexity of its structure, and analysing it with multilevel methodology. In particular, multilevel structural equation modelling has never been used to analyse this model of relationships. Thus, the present study provides a contribution to deepen this kind of approach in safety climate research, permitting to properly analyse relationships between constructs at different organizational level.

As predicted, the integrated system of safety climate works: organizational safety climate positively and significantly predicts co-workers' and supervisor's safety climate, at individual level as well as at group level; the mediating role of supervisor's safety climate is weaker since it partially mediates the relationship between organizational safety climate and co-workers' safety climate at individual level and not mediates it at group level. Similarly, co-workers' safety climate mediates the relationships between organizational safety climate and safety behaviours, and between supervisor's safety climate and safety behaviours, at individual level but non at group level. These results, associated to the results of the models analysing the mediating role of co-workers' safety climate and supervisor's safety climate one by one, suggest that at the group level the association of supervisor's safety climate and co-workers' safety climate undermines or cancels the effects of both on safety behaviours. In particular, it seems that co-workers' safety climate undermines the effect of supervisor's safety climate. In this regard the research by Chiaburu et al. (2009) evidences that co-workers matter uniquely in relation with supervisor's influence and, moreover, that co-workers' support was more predictive than leader support for many employees outcomes. These results are confirmed by the findings of the present research, in which the model with the mediating role of co-workers' safety climate only was more predictive of safety behaviours than the model with the mediating role of supervisor's safety climate only, at individual level ($R^2 = .39$ instead of .31) as well as at the group level ($R^2 = .75$ instead of .69). Similarly, in the final model, the relationship between co-workers' safety climate and safety behaviours was stronger – at individual and group level – than the one between supervisor's safety climate and safety behaviours (see Figure 4). These findings suggest that lateral relationships of supervisor's safety climate and co-workers' safety climate should be explored more deeply in the future, analysing the interactions between the roles of these safety agents. In this regard Chiaburu et al. (2009) underlined the importance of studying these relationships because the research about the boundaries of lateral relationships and the kinds of reciprocal influences (e.g. additive, interactive, or compensatory) emanating from all social agents in the organization are not investigated and are scarcely theorized.

Another interesting result of the current study is that the integrated model of safety climate was more predictive of safety participation than of safety compliance. These results confirmed previous findings (e.g. Griffin & Neal, 2000; Christian et al., 2009) that safety climate has more influence on behaviours that are contextual, since workers must by definition comply with obligatory procedures and practices. This support the idea that when individuals perceive there is a safe working climate in their organization, they will reciprocate by putting effort to discretionary safety activities. Therefore, as many scholars and practitioners suggest, organizations, attempting to improve safety, should focus on improve safety climate perception to motivate people to actively participate in safety activities, rather than simply blaming and punishing individuals who fail to comply with standard work procedures. In addition, our findings with regard to specific climate dimensions suggest key intervention points referred to improving workplace safety. For instance, interventions focused on improving the safety communication among colleagues, or co-workers' commitment to safety may meaningfully improve safety performance.

This study has limitations that should be taken into account when interpreting the results. First, the use of self-report measures to test all the dimensions of safety climate scales is a limit, because in this way the estimates of the relationships between the measures may be confounded by common method variance. Second, objective measurement of safety behaviours is needed to assess more properly the relationship between safety climate integrated system and safety behaviours. Third, the complexity of the model and the sample size at the group level did not permit to specify random slopes to assess cross-level interactions. Because of the limited sample size at the group level, also the power of the analysis might have been limited and not significant results need to be treated with caution.

Another limit was the small number of involved organizations which did not permit to study organizational safety climate at a proper level.

Furthermore, recent works suggest that it is important to study climate considering not only climate level but also climate strength, and that relationships between climate and outcomes are generally greater within strong climate. In the present work we chose to consider only groups which had quite strong climate to check the relationship between the integrated system of climates and safety behaviours in a sample where it was sure that there was climate, and so that the presence of a weak climate did not disturb the analysis of the relationships. In future researches, it would be interesting to consider the potential moderating role of climate strength, to deeply understand the dynamics among safety climates, and between the integrated system and safety behaviours.

Finally, to deepen the relationship between the integrated system of safety climates and safety behaviours, it could be useful to assess the mediating role of safety performance determinants: safety knowledge and safety motivation (Campbel et al., 1993; Neal, Griffin & Hart, 2000). Many scholars (e.g. Christian et al., 2009; Sinclair, Martin & Sears, 2010) explored the mediating role of these constructs, and found that safety determinants strongly predicted safety performance components. Studying these relationships, integrated in a larger system of variables, with a multilevel approach, could be useful to better understand mechanisms that influence safety behaviours at different organizational levels and therefore to have instruments to understand how improve safety in a ever more effective way.

Table 3.1
Characteristics of the Companies

Company	Products	Company size	Work-groups	Participants	% of participants on the total number of the blue-collars	Micro-accidents in the last 6 months (% of one ore more, self-report)	Injuries in the company (% of one ore more, self-report)
1	electric and petrol driven chainsaws, brush cutters and hedge cutters.	large	49	540	55%	17%	31%
2	metal furniture for super- and hyper-markets	small	13	81	85%	41%	37%
3	Cooling, conditioning and purifying systems	medium	10	114	95%	17%	34%
4	electrodes and metal wires	small	6	32	90%	19%	34%
5	Excavators and Trucks	medium	13	224	88%	6%	53%
Totale			**91**	**991**	**82,60%**		

Table 3.2
Characteristics of the Participants

Variables		N	%
Gender	male	850	86%
	female	137	14%
Age	18-25	54	6%
	26-35	229	24%
	36-45	385	40%
	46-55	253	26%
	> 55	36	4%
Nationality	Italian	745	75%
	foreign	246	25%
Educational level	< 5 y	56	6%
	5 – 8 y	366	38%
	9 – 13 y	433	44%
	> 13 y	118	12%
Years of work experience in the company	< 1 y	47	5%
	1- 5- y	235	25%
	> 5 y	658	70%
Injuries involvements in the company in the last 2 years	none	614	63%
	one	221	23%
	more than one	141	14%
Micro-accidents in the last 6 months	none	812	83%
	one	75	8%
	more than one	90	9%

Table 3.3
Results from Analysis on Between-group Variability

Construct	F	Degree of fredom	*p*	ICC
Org. - safety communication	3.21	63	< .001	.14
Org. - safety training	4.74	63	< .001	.22
Org. - safety systems	3.91	63	< .001	.18
Org. - values	3.97	63	< .001	.18
Sup. - Reaction to workers behaviours	4.17	63	< .001	.20
Sup. - effort to improve safety	5.67	63	< .001	.26
Co-w. - safety communication	2.60	63	< .001	.11
Co-w. - safety mentoring	3.03	63	< .001	.14
Co-w. - safety systems	3.60	63	< .001	.16
Co-w. -values	3.94	63	< .001	.18
Safety compliance	3.32	63	< .001	.16
Safety participation	2.88	63	< .001	.14

Table 3.4
Descriptive Statistics for Study Variables

Construct	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
OSC. S. Comm.	3.83 (3.86)	1.53 (.89)	-	.83	.97	.94	.86	.87	.81	.90	.89	.89	.74	.79
OSC. S. Train.	4.40 (4.42)	1.54 (1.01)	.71	-	.90	.85	.72	.86	.63	.77	.72	.83	.67	.68
OSC. S. System	4.52 (4.57)	1.43 (.86)	.67	.70	-	.98	.86	.90	.84	.95	.91	.93	.80	.83
OSC. S. Values	3.83 (3.88)	1.53 (.91)	.73	.68	.73	-	.84	.87	.83	.92	.91	.89	.86	.87
SSC. Reactions	4.15 (4.21)	1.76 (1.25)	.58	.56	.62	.62	-	.94	.76	.80	.84	.85	.77	.81
SSC. Effort	3.78 (3.81)	1.75 (1.14)	.63	.57	.58	.63	.82	-	.77	.83	.83	.84	.63	.70
CSC. S. Comm.	3.38 (3.45)	1.54 (.74)	.37	.37	.34	.37	.47	.41	-	.93	.88	.93	.79	.84
CSC. S. Train.	3.76 (3.83)	1.68 (.93)	.43	.41	.43	.45	.55	.54	.73	-	.92	.96	.73	.78
CSC. S. System	3.42 (3.52)	1.65 (.94)	.36	.36	.35	.39	.46	.47	.76	.74	-	.93	.84	.88
CSC. S. Values	3.81 (3.89)	1.59 (.94)	.46	.43	.47	.52	.54	.58	.67	.75	.67	-	.75	.79
Compliance	5.49 (5.55)	.99 (.44)	.27	.27	.34	.33	.36	.33	.26	.32	.31	.34	-	.99
Participation	4.74 (4.80)	1.16 (.53)	.35	.33	.33	.36	.37	.32	.43	.42	.41	.42	.52	-

Note. Means and standard deviations without parentheses are based on individual-level data (N = 895) and means and standard deviations in parentheses are based on group-level data (N = 64). Correlations below the diagonal are based on individual-level data and correlations above the diagonal are based on group-level data. All individual-level correlations and group level correlations are significant at **. * $p < .05$., ** $p < .01$. *** $p < .001$.

Table 3.5
Fit Indexes for Measurement and Structural Models

Model	χ^2 (df)	*p*	CFI	TLI	RMSEA	$SRMR_w$	$SRMR_b$
Measurement Model	364.62 (99)	.001	.96	.95	.06	.04	.05
Within Model	378.24 (100)	.001	.96	.95	.06	.04	.05
Hypothesized Multilevel Model	380.83 (101)	.001	.96	.95	.06	.04	.05
Final Multilevel Model	366.98 (99)	.001	.96	.95	.06	.04	.05
Model OSC → SSC → Beh.	144.77 (38)	.001	.97	.96	.06	.02	.05
Model OSC → CSC → Beh.	226.19 (68)	.001	.97	.96	.05	.03	.05
Final Mod. with Safety Compliance	349.72 (82)	.001	.96	.94	.06	.03	.11
Final Mod. with Safety Participation	343.14 (82)	.001	.96	.95	.06	.03	.11

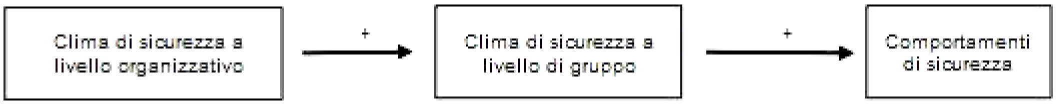

Figure 3.1. Zohar & Luria model (Zohar & Luria, 2005)

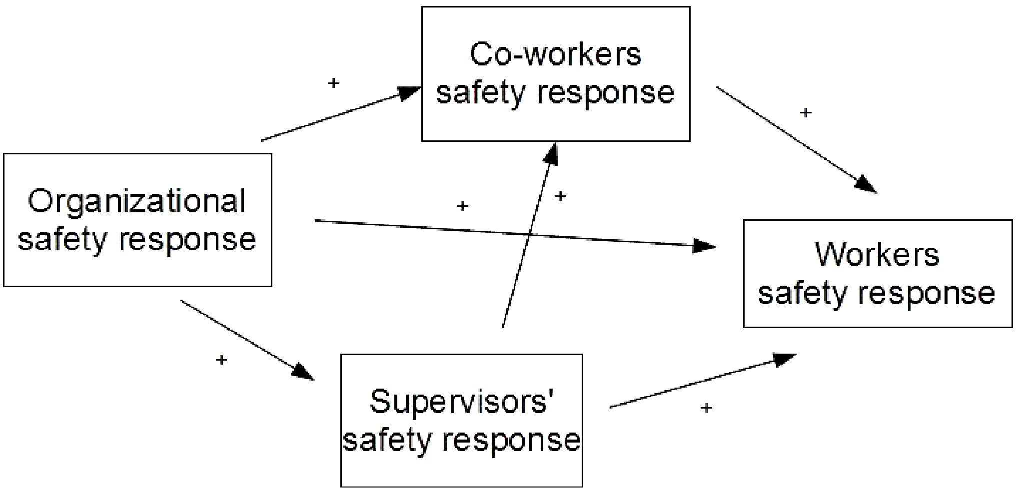

Figure 3.2. Model of Melià et al. (2008)

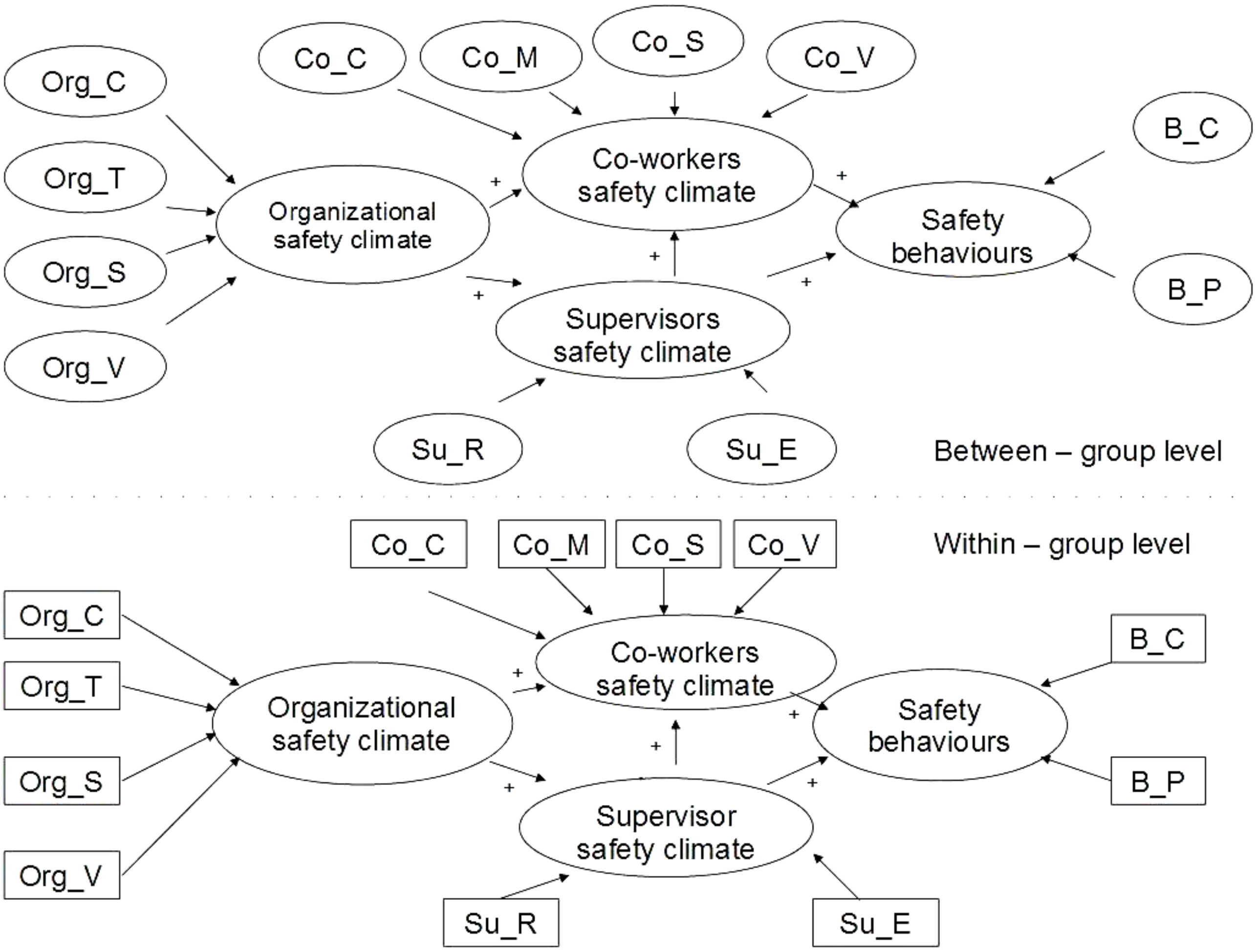

Figure 3.3. Conceptual multilevel model of safety climates framework associated to safety outcomes

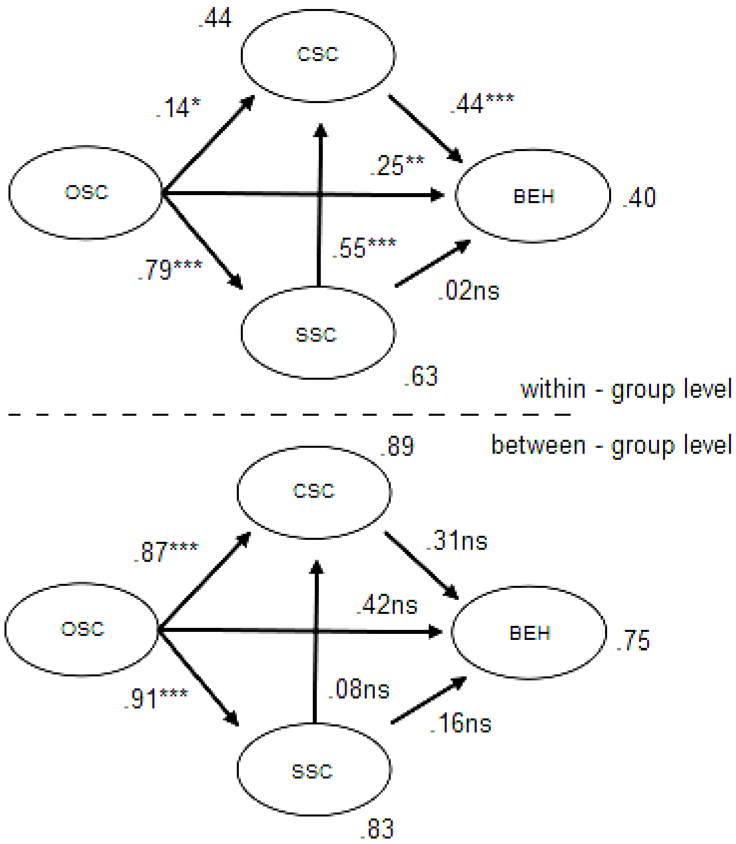

Figure 3.4. Results for Final Integrated Model

Note: Beside latent variables accounted variability is shown. * p < .05., ** p < .01. *** p < .001.

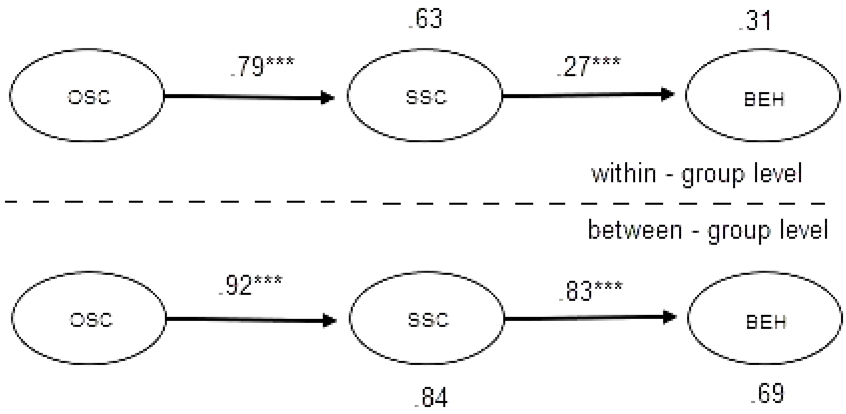

Figure 3.5. Results of the Model with Supervisor's Mediating Role

Note: Beside latent variables accounted variability is shown. * p < .05., ** p < .01. *** p < .001.

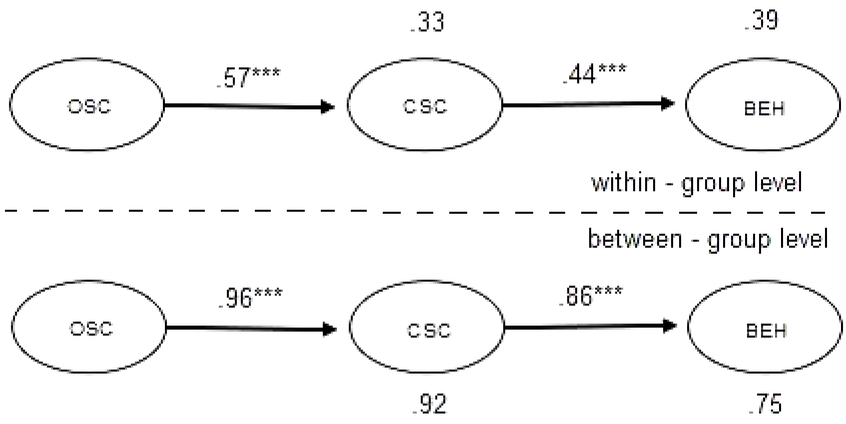

Figure 3.6. Results of the Model with co-workers' Mediating Role

Note: Beside latent variables accounted variability is shown. * p < .05., ** p < .01. *** p < .001.

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Capitolo 4

An integrated system of safety climates as leading predictor of safety performance and safety outcomes: a study on Italian metal-mechanic sector

Abstract

Griffin & Neal (2000) and then Christian, Bradley, Wallace, & Burke (2009) proposed a conceptual framework to organize relationships between antecedents and safety criteria, and tested this structure with a meta-analytic path modelling. The aim of the present research is to combine this conceptual framework with an integrated system of safety climates inspired by Zohar and Melià studies on safety climate, and to study the resulting model in a multilevel perspective. In this model co-workers' safety climate (CSC) and supervisor' safety climate (SSC) are considered as mediators in the relationship between safety climate at the organizational level (OSC) and determinants (safety motivation and safety knowledge) and components (safety compliance and safety participation) of safety performance. A two-level design which considered the individual level and the work-group level was performed. Data collection involved 673 blue-collars, belonging to 63 work groups, from 5 Italian manufacturing companies. The results confirm the mediating role of safety performance determinants in the relationships between the safety climates system and safety performance and the role of the system of safety climates as leading predictor of safety performance.

Introduction

Many reviews (e.g. Guldemund, 2000; Glendon, 2008, Seo, Torabi, Blair and Ellis,2004) and meta-analytic studies (e.g. Clarke, 2006; Nahrgang, Morgenson and Hofmann, 2008; Christian, Bradley, Wallace, & Burke, 2009) performed in last thirty years indicate that safety climate results a meaningful predictor of safety performance behaviours. Christian et al. (2009) identified a conceptual framework to organize relationships between antecedents and safety criteria and tested this structure with a meta-analytic path modelling. Christian et al. (2009) conceptual framework refers to Neal & Griffin (1997) model of safety performance, which was based on theories of job performance elaborated in nineties (e.g. Campbell, McCloy, Oppler, & Sager, 1993; Borman & Motowidlo, 1993). The model of Neal & Griffin (1997), later revised by the same authors (Griffin & Neal, 2000), proposed a framework where safety motivation and safety knowledge have a mediational role in the relationships between safety climate and safety performance components (compliance and participation). In the work by Christian et al. (2009), model safety climate is considered a distal situation-related antecedent of safety performance; safety knowledge and safety motivation are considered proximal person-related factors which determine safety performance and safety outcomes (injuries and micro-accidents); safety compliance and safety participation are the two components of safety performance. The present study has the aim of integrating this conceptual framework with Zohar and Melià studies on safety climate in a multilevel perspective, focusing on safety climate at the group level introducing safety climate referred to co-workers. Co-workers' safety climate (CSC) and supervisor' safety climate (SSC) are considered as mediators in the relationship between safety climate at the organizational level (OSC) and determinants and components of safety performance. In particular, we have three goals for the current study:

to integrate the model of Griffin and Neal, and hence the model of Christian and colleagues, with group level studies on safety climate by Zohar and Melià (see previous chapter); to explore the specific role of determinants (knowledge and motivation) as antecedents of safety behaviours' components and safety criteria and to test the resulting model on an industrial sample by a multilevel structural equation modelling analysis.

Safety climate

Zohar & Hofmann (2010) proposed a distinction between two different perspectives to analyse organizational climate: climate as a global perceptions (e.g. Ostroff, 1993) and climate as domain-specific perceptions (e.g. Schneider & Reichers, 1983). In a domain-specific perception approach, safety climate is considered as a specific organizational climate on the strategic focus of safety. Hence if organizational climate is commonly defined by perceptions of policies, procedures, and practices that operate in the work environment, organizational safety climate refers, more specifically, to the shared perceptions of policies, procedures, and practices relating to safety (e.g. Griffin & Neal, 2000; Zohar, 2003).

A multilevel construct

Safety climate can be studied at three levels: organizational level, group level, and individual level. Organizational and group safety climates have been largely investigated separately, dealing either with one construct of analysis or the other one (Zohar, 2000). Nevertheless, many scholars underlined that organizational processes take place simultaneously at several levels and that processes at different levels are linked in some way (e.g. Kozlowski & Klein, 2000; Shannon & Norman, 2008). In other words, processes taking place at one hierarchical level have an influence on other levels. Concerning safety climate, this implies that climates have different meanings at different organizational levels, as well as cross-level relationships.

Zohar (2010) stated that some assumptions are required to make climate a multilevel construct. The first assumption is that top managers elaborate policies and procedures and supervisors at lower hierarchical levels execute these policies and associated procedures, interacting with people belonging to their work groups. This can create a discrepancy between formal and executed policy. Therefore, it is important to study safety climate distinguishing the different agents it concerns (e.g. top management at organizational level and supervisors at group level). Another assumption concerns employees capability to distinguish between procedures defined by top management and procedures executed by supervisors and between supervisor's behaviours backed by company management and supervisor's behaviours decided by their own self. Together, these assumptions explain the important cross-level phenomenon of group level variation within a single organization-level climate and underlines the importance to distinguish safety climate at organizational, at group, and at individual level.

At the individual level, climate perceptions are defined as *psychological climate* (James, Hater, Gent and Bruni, 1978), that is "the individual's cognitive representations of relatively proximal situational conditions, expressed in terms that reflects psychologically meaningful interpretations of the situation" (James, Hater, Gent and Bruni, 1978, p. 786).

At the group level, safety climate could refer to supervisor (e.g. Zohar, 2000; Zohar & Luria, 2005; Melià & Sesè, 2007) and to co-workers' practices (e.g. Singer et al., 2007; Melià et al, 2008; Jiang et al., 2009). At the group level, perceptions are aggregated within subunits, and usually supervisory emphasis is the primary referent object. Zohar (2000, 2010) states that the key issue in group-level safety climate variation relates to supervisory practices and gives evidence that organizational-level safety climate positively influences supervisor's safety climate, which is, in turn negatively related to safety outcomes.

The role of co-workers has not been explored as much as the role of the supervisor. Only very few studies consider co-workers as agent of a specific safety climate different from supervisor's safety climate (e.g. Melià et al, 2008). Chiaburu & Harrison (2008) on the basis of the tenets of interdependence theory (Kelley & Thibaut, 1978), show, in their research, that co-workers' support and antagonism have a unique effect on employees' outcomes beyond that of leader influences and that co-worker support has a strong positive relationship with task performance. Melià et al. (2008) identify the co-worker as an important safety agent side by side the organization and the supervisor and show that organizational safety climate and supervisor's safety climate positively and significantly predict co-worker safety climate. At the organization level, climate perceptions are aggregated across the company, and organizational-level emphasis on safety is the referent object. Organizational level safety climate has been extensively studied, as reviewed in many meta-analytic and traditional reviews on safety. Many studies (e.g. Zohar & Luria, 2005; Neal & Griffin, 2006; Probst, Brubaker & Barsotti, 2008; Dal Corso, 2008; Cavazza & Serpe, 2009; Christian et al., 2009) showed a positive strong relationship between organizational safety climate and safety outcomes, but also between organizational safety climate and group safety climate (e.g. Zohar, 2005, Melià et al., 2008).

Safety performance

The conceptual framework built by Christian et al. (2009) describes the relationships between antecedents, safety performance, and safety criteria. The authors developed this framework on the basis of Neal and Griffin modelling work, inspired by studies on performance published in nineties (Campbell et al., 1993; Borman & Motowidlo, 1993). In particular, Campbell et al. (1993), discussed preview definitions and conceptualizations of job performance with specific issues: “(1) the general factor cannot possibly represent the best fit, (2) the notion of an ultimate criterion is a false issue, (3) the subjective versus objective distinction is a false issue, and (4) there is a critically important distinction to be made between performance and the results of performance” (p. 38). Subsequently, the authors gave their definition of performance, stating that it is a synonymous with behaviour, that is something that people do and that it can be observed, consisting of “those actions or behaviours that are relevant to the organization's goals and that can be scaled (measured) in terms of each individual's proficiency” (p. 40). They also distinguished between performance components, determinants, and antecedents of performance.

Safety performance components

In Campbel et al. (1993) model's performance components are specific types of behaviours that people are expected to act at work. Borman & Motowidlo (1993) distinguish two main components of performance which can be considered to type job performance at work: task performance and contextual performance. Griffin & Neal (2000) adopted this categorization for safety behaviours at work, distinguishing between safety compliance and safety participation. Related to the definition of task performance, safety compliance can be viewed as all the behaviours concerning adhesion and respect to safety procedures and work in a safe manner (e.g. using properly personal protective equipment). Related to the definition of contextual performance, safety participation means helping co-workers, promoting voluntary safety programs, putting everybody’s own effort to improve safety at work. The division between safety compliance and safety participation was supported by the results of the research of Griffin and Neal (Griffin & Neal, 2000; Neal et al, 2000; Neal & Griffin, 2004, 2006). This is important, because it allows to distinguish between safety activities that are included in the job and safety activities that support the broader organizational context and it allowed to explore the processes linking safety climate to specific performance components.

Safety performance determinants

Campbel et al. (1993) identify three main determinants that can explain the individual differences about every specific component: motivation, declarative knowledge, procedural knowledge and skill. They state that motivation is always a determinant of performance, since performance does not happen if the subject does not choice to perform, with a certain level of effort and at a specific moment. Basing on the previews findings in cognitive research (e.g. Ackerman, 1988) the authors distinguish the other determinants of performance and try to describe the relationships between them. Griffin and Neal (2000) considered only two determinants of safety performance: safety motivation and safety knowledge. Furthermore, they distinguished between safety compliance motivation and safety participation motivation to deeply explore the relationship between safety motivation and safety performance components. The results of their studies (e.g. Griffin & Neal, 2000; Neal, Griffin & Hart, 2000) supported the mediational role of knowledge and motivation between safety climate and safety performance components. In particular, they found that participation motivation was strongly related to safety participation, that compliance motivation was weakly linked to safety compliance and, unexpectedly, that compliance motivation was negatively related to safety participation. Safety knowledge resulted strongly predicted by safety climate and was strongly predicting safety performance components. Griffin & Neal (2000) final model is shown in Figure 1. The above mentioned general framework was also confirmed by Christian et al. (2009) meta-analytic path analysis work. In addition to what shown by Griffin & Neal, they underlined the capability of the model of predicting safety outcomes (accidents and injuries) (β

= -.31). Moreover, their path model made evidence, as theoretically suggested (e.g. Colquitt, LePine & Noe, 2000), that safety motivation lead to safety knowledge acquisition (.55).

The proposes of the present study are to test Griffin & Neal (2000) structural equation model and Christian et al. (2009) path model in our sample, to integrate Griffin & Neal framework with safety climates model identified in the previous chapter, to study the specific role of each safety performance determinant (knowledge and motivation) as antecedents of safety performance components and safety criteria and to explore the integrated model with multilevel structural equation modelling analysis distinguishing group and individual level. Empirical evidence (e.g. Griffin & Neal, 2000; Christian et al., 2009) showed a full mediation model in which safety performance determinants completely mediate the relationship between safety climate and safety performance. On the basis of this empirical evidence and of previous performance research (Campbel et al., 1993; Borman & Motowidlo, 1993; Chiaburu et al., 2008), the integrated model was built hypothesizing a full mediating role of safety performance determinants between safety climates system and safety performance components.

Method

Participants

The present study was supported by Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro (INAIL, that is the OSH national institution of Italy[13]) of Vicenza and by

[13] INAIL is an Italian institution pursuing several objectives: the reduction of accidents at work, the insurance of workers involved in risky activities; the re-integration in the labour market and in social life of work accident victims.

INAIL of the Veneto Region, and by the three main Italian federations of metal workers (Federazione Italiana Metalmeccanici (FIM) Federazione Impiegati e Operai Metallurgici (FIOM), Unione Italiana Lavoratori Metalmeccanici (UILM)) The study study regarded the metal-mechanic sector companies involving the main branches of metal-mechanic work.

Regarding dimension, we chose to collect data in small, middle, and large size organizations on the basis of the number of the employees, considering three level sizes: small (from 0 to 50 employees); medium (from 50 to 100) and large level (100 and beyond).

From the geographical point of view, attention was focused on a specific area, such as the region of Veneto, a high-developed industrial zone with a high rate of accidents on workplace, particularly in the metal-mechanic sector, which is one of the most relevant industrial sector of this region.

Five companies (one small, two medium and two large companies) agreed to participate to the study. A mean percentage of 84% of the blue-collars of the companies was involved.

A one-level design was used, considering the work-group level. All data was collected at individual level, and data collection involved 714 blue-collars. Considering the group level, for each participant the work-group was registered, and the total number of work-groups in the five companies was 81. Table 1 shows some characteristics of the five companies.

Considering the whole sample, 20% of the participants were female; 93% were Italian workers; 90% had an educational level from 5 to 13 years of school; only 3% of the participants had been working in the company for less than 1 year, and 71% had been working for the same company for 5 years or more; 80% of participants had a permanent contract. Table 2 shows some characteristics of the participants.

Measures

In chapter 2 we illustrated the development of the safety climate measures (Organizational safety climate, Supervisor's safety climate and Co-workers' safety climate) used in the present work as these domains are thought for a safety climate scale at organizational level, for supervisor and co-workers' scales Griffin & Neal' s domains were adjusted to these specific safety agents.

Organizational safety climate (OSC) is measured with a 12-item scale in which the target of the safety climate judgement given by the worker is the entire organization. This scale is the result of a validation process merging items (ten items) from the Multilevel Safety Climate Scale of Zohar & Luria (2005) with items (two items) from the Safety Climate Scale of Griffin & Neal (2000, personal communication), as explained in the previous chapter. Items are accompanied by a 7-point rating scale, ranging from 1 (never) to 7 (always).

Each item of OSC scale is connected to one of the four domains identified by Griffin & Neal (2000, personal communication): Management values, Safety systems, Safety communication, and Safety training. Management values concern how managers valued safety in the workplace, with items such as *"Top management considers safety when setting production speed and sc*hedules". Safety systems refer to the effectiveness of safety systems in the organization, for example *"Top management provides all the equipment needed to do the job safely".* Safety communication is about how safety issues are communicated, for example *"Top management listens carefully to workers' ideas about improving safety".* Safety training refers to the quality and quantity of the employees' s opportunities to be trained, including items such as *"Employees receive comprehensive training in workplace health and safety issues".* Since the previous chapter was focused on the validation of the three safety climate scales, for each safety climate scales only alpha reliability, Construct Reliability (CR) and Average Variance Extracted (AVE) were reported. Alpha reliability of this scale was .95. Construct Reliability and Average Variance Extracted for each first-order factor were calculated: values (CR .83; AVE .61), safety system (CR .80; AVE .58), safety communication (CR .76; AVE .52) and training (CR .83; AVE .61). All the values were above the fixed threshold (.70 for construct reliability and .50 for variance extracted as suggested by Hair, Anderson, Tatham & Black, 1998).

Supervisor's safety climate (SSC) is assessed by a 10- item scale in which the workers had to judge the real importance given to safety by their direct supervisor in the work-group. This is an adjusted version of the Group-level Safety Climate scale by Zohar & Luria (2005). Items are accompanied by a 7-point rating scale, commensurate with the organizational level scale. Each item of SSC scale refers to two domains identified as supervisor reaction to the workers' safety behaviours (for example *"My direct supervisor is strict about working safely when we are tired or stressed"*) and supervisor's own safety behaviour and effort to improve safety (for example "*My direct supervisor uses explanations (not just compliance) to get us to act safely")* (Melià & Sesé, 2007; Zohar, 2000) (see Table 3). Such as for the OSC scale, psychometric properties of SSC scale were assessed with multilevel confirmatory factor analysis in chapter 2. Alpha reliability of this scale was .96. Furthermore CR and AVE for each first-order factor were calculated: first factor (CR .91; AVE .64); second factor (CR .89; AVE . 67).

Co-workers' safety climate (CSC) was measured with a 12-item scale in which the target of the safety climate judgement given by the workers is if safety is a real priority of their colleagues. Like in the previous safety climate scales, responses were given on a 7-point Likert scale, from 1 = "never" to 7 = "always". The items of CSC Scale were derived from the adjustment to co-workers of the group level safety climate scale of Zohar & Luria (2005) and comparing the resulted items with items content of co-workers' scales by co-workers' safety climate literature (e.g. Fugas, Silva and Melià, 2009; Singer et al., 2007; Melià, 1998; Melià and Becerril, 2006; Melià et al, 2008; Jiang et al., 2009). Each item of CSC scale is connected to one of the four domains identified by Griffin & Neal (2000, personal communication): Co-workers' values, Safety systems, Safety communication, and Safety Mentoring. The Griffin & Neal's dimension of 'Training' was changed into 'Mentoring', which was more suitable to the co-workers' role. This dimension refers to co-workers' activities oriented to support colleagues to improve their safety behaviour (i.e. giving them suggestions, calling attention to safety). Co-workers' values concern the degree to which co-workers valued safety in the workplace, represented by items such as *"My team members are careful about working safely also when we are tired or stressed.*". Safety systems refer to the attention about safety systems by co-workers, for example *"My team members are careful that the other members receive all the equipment needed to do the job safely.*". Safety communication is about the way in which safety issues are discussed in the team work, for example *"My team members talk about safety issues throughout the work week*". An example of item of Mentoring domain in the CSC scale is "*If it is necessary, my team members use explanations to get other team members to act safely*". Such as for the previous scales, psychometric properties of the scale of the individual perception items are assessed with multilevel confirmatory factor analysis. Alpha reliability of this scale was .95. Furthermore CR and AVE for each first-order factor were calculated: values (CR .86; AVE .67), safety system (CR .90; AVE .76), safety communication (CR .84; AVE .64) and Mentoring (CR .89; AVE .73).

Safety motivation is measured with a 9-item scale which refers to workers safety behaviours. The scale is the Italian version of Griffin & Neal scale about safety behaviour (personal communication). Two components of safety motivation are measured: compliance motivation (4 items) and participation motivation (5 items). Responses were given on a 7-point Likert scale, from 1 = "*not at all*" to 7 = "*very much*". Compliance motivation is assessed by four items that asked about motivation to perform safety-related tasks (for example "*I believe that it is important to always use safe/ standard work procedures*"). Participation motivation is assessed by five items about motivation to participate in activities supporting safety in the organization (for example "*I believe that it is worthwhile to put extra effort into maintaining safety*"). A model with a second-order factor (safety motivation) and two first-order factors (compliance motivation and participation motivation) was estimated. Psychometric properties of the scale are assessed with confirmatory factor analysis. Also in this case the estimated model provided a good fit indices, $\chi2_{(25;\ N\ =\ 673)} = 145.32$, $p < .001$, CFI = .94; SRMR = .046. Alpha reliability of this scale was .80. Furthermore CR and AVE for each first-order factor were calculated: compliance Motivation (CR .86; AVE .61) and participation motivation (CR . 83; AVE .49).

Safety knowledge is measured with a 4-item scale which refers to worker knowledge of safety practices and procedure. The scale is an adjusted version of Griffin & Neal scale about safety knowledge (2000, personal communication). An example of item is "*I know how to use safety equipment and standard work procedures*"). Responses were given on a 7-point Likert scale, from 1 = "*not at all*" to 7 = "*very much*". Psychometric properties of the scale are assessed with confirmatory factor analysis. Also in this case the estimated model provided a good fit indices, $\chi2_{(2;\ N\ =\ 673)} = 26.53$, $p < .001$; CFI = .97; SRMR = .033. Alpha reliability of this scale was .80. For this measure construct reliability and average variance extracted were not calculated because knowledge had a one factor structure.

Safety performance is measured with a 8-item scale which refers to workers safety behaviours. The scale is an adjusted version of Griffin & Neal scale about safety behaviour (2000, personal communication). Two components of safety performance are measured: safety compliance (4 items) and safety participation (4 items). Responses were given on a 7-point Likert scale, from 1 = "*not at all*" to 7 = "*very much*". Safety compliance is assessed by four items that asked about individual performance of safety compliance (for example "*I use all the necessary safety equipment to do my job*"). Safety participation is assessed by four items about participation that support safety in the workplace, but do not necessarily involve performance related to safety (for example "*I put in extra effort to improve the safety of the workplace*"). A model with a second-order factor (safety behaviour) and two first-order factors (Safety Compliance and Safety Participation) was estimated. Psychometric properties of the scale are assessed with confirmatory factor analysis. In this case, also, the estimated model provided good fit indices, $\chi2_{(18;\, N = 594)} = 63.35$, $p < .001$; CFI = .97; SRMR = .039. Alpha reliability of this scale was .80. Furthermore CR and AVE for each first-order factor were calculated: Compliance (CR .81; AVE .51) and Participation (CR .70; AVE .37).

Injuries were assessed with self-report data. Workers were asked about the number of injuries happened since they have entered the company. Responses were given in absolute number, and were then codified in three classes: 0, 1, more than 1.

Micro-accidents were assessed in the same way as injuries. Workers were asked for the number of micro-accidents happened in the previous 6 months. As for injuries, responses were given in absolute number, but were then codified in three classes: 0, 1, more than 1.

Other questions in the questionnaire

A number of socio-demographic questions were collected, regarding gender, age, educational level, nationality, length of employment in the company, kind of job-contract, department, work shift at the moment of the survey.

Procedures

Few days before administering the questionnaire, either the top management organized an *ad hoc* meeting with unions, the Safety Commission and the safety officer or a trade-union meeting was held and workers were told that they were part of a larger sample of workers involved in a research supported by INAIL, and received information about the research program. Participants were informed that the questionnaire was anonymous, and all data were collected and conserved by the research group. They were also ensured that only aggregate results would be given to the management of the company.

All participants answered the questionnaire during working hours, at the end or at the beginning of their work shift, and were asked to answer as sincerely as possible. They were told that items concerned with their perception of organizational management, direct supervisor, and work-group co-workers about safety at works¸ they were told that, in case they found difficult to answer to an item, due to ignorance of something regarding, for instance, organizational policy, they should choose the answer which was closest to the their perception. At the end of the questionnaire participants were asked to answer questions about some socio-demographic data. Along with the Italian questionnaire, English and a French translations were also provided for foreign workers. Researchers were available during all time, to help participants, if necessary. The duration of the whole procedure was about 20 minutes.

Data analysis

Confirmatory factor analysis (CFA) was used to test construct validity of determinants and components of safety performance. Safety climate constructs were already assessed in chapter 2. To assess the hypothesized mediational model at the individual level structural equation modelling (SEM) were applied. CFA and SEM at the individual level were performed with R Statistical Package. To test the hypothesized mediational model at multiple levels, data were analysed with multilevel structural equation modeling (ML-SEM) with M*plus* 5.1 (Muthén & Muthén, 1998–2008). The present study used the example M*plus* syntax created by Preacher, Zyphur, and Zhang (2010) as a starting point for developing the syntax of multilevel models. In ML-SEM, the variability of variables is decomposed into two latent components, a within-group (i.e. variability at individual level) component, and a between-group (i.e. variability at group level) component (Muthén & Asparouhov, 2009).

ML-SEM permits to model the relationships among these variance components within each level through the specification of measurement and structural models. At the individual level variables can be specified as having intercepts (and random slopes) that vary across groups. At the group level the random intercepts are modelled as latent variables. In the present study, no random slopes were specified, because the complexity of the model and the limited number of work groups not permitted to study cross-level interactions. However, random intercepts were specified for safety climate indicators (organizational, supervisor, and Co-workers' safety climate), for safety motivation, safety knowledge and for safety behaviours, (see Figure 5). Furthermore, ML-SEM provides a more precise estimate of indirect effects in models with variables at multiple levels of analysis because of the manner in which variance is decomposed into two components, hence enabling to avoid problems of merging individual level effect with group level effect (Preacher et al., 2010; Zhang, Zyphur, & Preacher, 2009).

The present study followed several steps to do ML-SEM analyses referring to Preacher et al. (2010) and Muthén (1994) procedures. Before conducting multilevel ML-SEM analyses some preliminary operations were carried out.

The first step regards between-group variability to support ML-SEM. First, the composition of work group was analysed. Only groups composed of workers within the same department, working in the same shift and with the same supervisor were selected. Subsequently, the size of each group was analysed due to the fact shared perceptions about climate need the presence of a group. Climate scholars[14] usually indicate as minimum size of a group three or four members. Therefore, Groups with less than 4 members were eliminated from the sample. The variability between groups on each variable was examined by computing the intraclass correlation (ICC). Muthen (1994) suggested to estimate a unique type of ICC to determine potential group influence. Muthen's ICC index is conceptually similar to ICC(1). The difference between the two indexes is that Muthen's ICC is obtained by random effects ANOVA, while ICC(1) is obtained by fixed effects ANOVA. ICC ranges in value from 0 to 1. If values are close to zero (e.g. .05) the multilevel modelling will be meaningless (Dyer, Hanges & Hall, 2005).

Homogeneity of climate perceptions was also assessed with $r_{wg(j)}$ (Bliese, 2000) for each work group (or unit) using a uniform null distribution for the safety climate indicators. This method was used to ensure that a sufficient level of within-group agreement was present in the variables for which we had substantive interest at the group level. Agreement was evaluated using LeBreton and Senter's (2008) revised standards for interpreting interrater agreement estimates. For the three group-level constructs, organizational, supervisor, and Co-workers' safety climates, it was found a level of agreement to support their inclusion (i.e., median values greater than or equal to .70; LeBreton & Senter, 2008). The agreement was not calculated for

[14] Personal communication with Dov Zohar, expert of safety climate. Dov Zohar is professor at the William Davidson Faculty of Industrial Engineering and Management Technion - Israel Institute of Technology.

safety performance determinants and components because the interest in the variables was at the individual level.

In the second step, the investigation of a properly specified within-group model was performed. In this step the attention was focused especially on the specification of the within-group structural model. Preacher et al. (2010) suggest two ways to fit the within-group model. The first one requires to group mean center all observed variables and then to fit the within-group model as a single level model. The second one involves fitting the full model, allowing the group-level constructs to freely covary. In the present study the second way to fit within-group model was performed.

In the third step, the hypothesized within-group and between-group structural model was analysed simultaneously. Due to the limited number of companies, it was impossible take into account the company as a third level of analysis. Therefore, organizational safety climate was considered a group level variable that can be interpreted as the shared perceptions of work groups on the real importance given to safety by the top management.

Goodness of fit of the models was also evaluated using the Tucker Lewis Index (TLI; Tucker & Lewis, 1973), the comparative fit index (CFI; Bentler, 1990), the root mean square error of approximation (RMSEA; Hu & Bentler, 1999), the standardized root mean square residual (SRMR). For TLI and CFI a value between .90 and .95 is acceptable, and above .95 is good. RMSEA is a global fit measure based on residuals; good models have an RMSEA of .05 or less. Models whose RMSEA is .10 or more have poor fit. RMSEA of .08 is acceptable (Hu & Bentler, 1999). SRMR indicates the closeness of predicted covariances matrix to the observed one; values of zero indicates perfect fit and a value less than .08 is considered a good fit. This measure tends to be smaller as sample size increases and as the number of parameters in the model increases. Also GFI and AGFI, that are common indexes in many SEM packages, are reported, even if they are affected by sample size and can be large for models that are poorly specified, and the current consensus is not to use these measures (Kenny, 2010 http://davidakenny.net/cm/fit.htm). Values close to .95 reflects a good fit.

Descriptive statistics and aggregation analysis

At first a specific analysis of the missing values frequency for each variable was conducted on the sample. All cases with more than 5% of missing values were removed (Chemolli & Pasini, 2007).

To be sure that this choice did not invalidate our sample, examination of missing values considering the socio-demographic characteristics was made, using chi square test. Then work-group with less than four member where eliminated. In Table 3 the results about variability between groups to support multilevel analyses are reported. Significant between-group variance was observed for all variables with ICCs ranging from .12 (CSC) to .28 (OSC). These values underlined the importance of conducting an ML-SEM because of the affection of group membership to individual level observation. The ICC values related to safety motivation, safety knowledge and safety performance had to be consider as a measure of the variability between groups of individual constructs. Furthermore, the median $r_{wg(j)}$ values across groups were analysed. The median values for organizational safety climate, supervisor's safety climate and Co-workers' safety climate were respectively .88 (OSC), .80 (SSC), and .89 (CSC), indicating a good homogeneity of climates perceptions inside groups. After the analysis of work groups composition and of homogeneity of climate perceptions, the sample size was composed of 671 cases and 63 work groups.

Then for each indicator mean and standard deviation were computed. Indicators were also checked for normal distribution, computing skewness and kurtosis and considering normally distributed all the items with values into the range -1/+1. Responses were approximately normally distributed, with skewness ranging from -1.19 to .67 and kurtosis values ranging from -.05 to 2.66. The few kurtosis and skewness values out of the range were not considered a problem since mean skewness (|M| = .54) and mean kurtosis (|M| = .59) were inferior to |1| (Muthen & Kaplan, 1985).

In Table 4 means, standard deviations, and bivariate correlations for the measures used in the present study are reported. From a review of the means it seemed that overall respondents perceived positive safety climate for all the safety agents, that they had a good level of safety knowledge, higher motivation to compliance than to participation and a higher level of behaviours of compliance than behaviours of participation.

Results

Griffin & Neal (2000) model was tested with structural equation modelling analysis. The measurement model was tested first. Organizational safety climate was estimated as a higher order factor with four specific first-order factor (safety communication, safety training, safety systems and safety values). All factor loadings were statistically significant and suggest that all items adequately reflected the latent constructs. The model provided an acceptable fit ($\chi2_{(476;\ N\ =\ 616)}$ = 1360.78, p < .001, CFI = .91, RMSEA= .06, SRMR = .05) (see Table 5). Next structural paths among the constructs were estimated (Figure 2). Fit indices were almost equal to those of the previous model ($\chi2_{(479;\ N\ =\ 616)}$ = 1398.95, p < .001, CFI = .91, RMSEA= .06, SRMR = .06). It was interesting that path estimates were very similar to those of Griffin & Neal (2000) final model (Figure 1). On average, path estimates for the present sample were a little higher than those of Griffin & Neal sample. It was also replicated the unexpected negative link between compliance motivation and safety participation. This relationship was justified referring to resource allocation models of performance that suggest goal-oriented task motivation can reduce participation in contextual behaviours (Griffin & Neal, 2000; Wright, George, Farnsworth, McMahan (1993). Finally, the model with the direct paths between organizational safety climate and performance components was estimated to assess the hypothesis of a fully mediation of safety determinants. The direct paths were statistically significant (.13, $p < .01$ for the link between OSC and safety compliance and .21, $p < .001$ for the link between OSC and safety participation, respectively) highlighting only a partially mediated structure. This last model was retained because it was better than the previous model ($\Delta\chi^2_{(2,\, N = 616)} = 27.46$, $p < .001$). Other fit indexes were equal to the previous model (CFI = .91, RMSEA= .06, SRMR = .05). The model accounted for 10% of variability of compliance motivation, 9% of variability of participation motivation; 12% of variability of safety knowledge, 81% of variability of safety participation, and 68% of variability of safety compliance.

In the next step, we tested a model which integrates Griffin & Neal framework with safety climates model identified in the previous chapter. At first the model studied in the previous chapter was estimated. Given the complexity of the path model and considering the dimension of the sample (714 participants[15]) it was considered more appropriated to conduct structural equation modelling analysis simplifying the structure of safety climate latent constructs. Safety climates (OSC, SSC and CSC) were estimated as first-order latent constructs comprised each one of its indicators which were the mean of items of each sub-scale

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[15] The total of participants were 714, but without participants with more than 5% of missing values and considering only groups with at least four members the sample became of 673, and finally without all missing values it was reduced to 616 cases.

[16] Bentler, & Chou (1987) suggested to calculate the sample size adequate to conduct a structural equation

. At first the measurement model was estimated. All factor loadings were statistically significant and suggest that all items adequately reflected the latent constructs. Fit indexes were acceptable ($\chi2_{(406;\ N = 616)}$ = 1223.94, p < .001, CFI = .92, RMSEA= .06, SRMR = .05). Then the hypothesized structural equation model were estimated. Fit indexes were very similar to those of the measurement model ($\chi2_{(413;\ N = 616)}$ = 1277.37, p < .001, CFI = .92, RMSEA= .06, SRMR = .055). Standardized path estimates were presented in Figure 3. Inspection of significant paths on average indicated higher values of coefficients in the relationships between determinants and components of safety performance. Supervisor's safety climate had not statistically significant direct paths with performance determinants.

Standardized total indirect effects of OSC on safety participation and on safety compliance were positive and statistically significant (safety participation: β = .42 p < .001, CI = .30, .53; safety compliance β = .34 p < .001, CI = .25, .43). Standardized total indirect effects of SSC on safety participation and on safety compliance were statistically significant for safety participation, but not for safety compliance (safety participation: β = .29 p < .01, CI = .07, .50; safety compliance β = .07 p >.05, CI = -.10, .25). The same results for SSC were found for CSC, that standardized total indirect effects of CSC on safety participation was statistically significant, but it was not statistically significant for safety compliance (safety participation: β = .27 p < .001, CI = .11, .44; safety compliance (β = .05 p >.05, CI = -.07, .17). These results, in combination with the lack of direct effects of OSC on safety participation or safety compliance support the hypothesized fully mediated relationships between OSC and safety participation, and OSC and safety compliance. The same results were found for the relationship

modelling analysis that five cases for each parameter to be estimate. The integrated model needed the estimate of 150 parameters. It means that at least 750 cases are needed.

between SSC and safety participation. The relationship between CSC and safety participation resulted partially mediated because of the presence of a statistically significant direct effect between CSC and safety participation. For the relationships between SSC and safety compliance and between CSC and safety compliance the standardized total indirect effects were not statistically significant.

Comparing the accounted variability for determinants and components of safety performance with that calculated for Griffin & Neal (2000) model, it is interesting to note that for compliance motivation and safety compliance remained almost the same (10% for compliance motivation and 67% for safety compliance respectively), but for participation motivation and safety participation the variability accounted by the integrated model consistently increased (17% instead of 9% for participation motivation, and 92% instead of 81% for safety participation). After that, we added one a time the relationships between safety performance components and safety outcomes (micro-incidents in the last 6 months and injuries in the last 2 years). For injuries both the relationships were not statistically significant. In the model with the insertion of micro-incidents the link between safety participation and and micro-incidents was not statistically significant, but the relationships between safety compliance and micro-incidents was negative and statistically significant ($\beta = -.15$ $p < .05$). Fit indexes were very similar of the integrated model ($\chi 2_{(442;\ N = 616)} = 1310.74$, $p < .001$, CFI = .92, RMSEA= .06, SRMR = .05). In Figure 4 standardized path estimates were presented.

This result confirmed what has been found by Christian et al. (2009) in their meta-analytic work.

Testing multilevel structural equation model

The next step was to explore the integrated model with multilevel structural equation modelling analysis distinguishing group level and individual level. Due to the complexity of the integrated model and the number of the work groups in the sample (63 work groups[17]), we considered more appropriate to conduct a multilevel path analysis and a further simplification of the model was needed[18]. To simplify the integrated model the authors referred to Christian et al. (2009) path model. In this model, safety climate was considered a distal antecedent of safety performance. As antecedent is supposed to directly influence safety knowledge and safety motivation, which, in turn, directly influence safety performance behaviours, which then directly linked to safety outcomes (injuries and micro-accidents). In the composition of the integrated model of safety climates with Christian et al. path model, the previous analysed motivation variables safety compliance motivation and safety participation motivation were found in one variable: safety motivation. Similarly safety compliance and safety participation were aggregated in safety behaviours.

At first an uni-level path analysis was conduct to test whether data replicate the results of Christian et al. (2009). The model showed a poor fit ($\chi2_{(1;\, N = 671)} = 77.69$, $p < .001$, CFI = .91, RMSEA= .34, SRMR = .06), although all the path estimates were statistically significant. The model accounted 25% of variability in safety knowledge, 7% of variability in safety motivation, and 56% of variability in safety behaviours. Then the integrated model was estimated. Fit indexes moderately improved ($\chi2_{(3;\, N = 671)} = 108.65$, $p < .001$, CFI = .94, RMSEA= .23, SRMR = .07). The accounted variability in endogenous variables increased a little (36% for CSC, 53% for SSC, 9% for safety motivation, 26% for safety knowledge, and 56% for safety behaviours). Inspection of significant paths in the saturated path model

[17] Sixty three were the work groups remained after the preliminary operations to conduct multilevel analysis.

[18] In ML-SEM the model is estimated at individual and at group level. For group level analysis the subjects are work group. Since the integrated model needed more than 63 observation it was necessary a simplification of the model.

suggested to add direct path between safety behaviours and safety climate variables and to eliminate direct path between OSC and safety motivation and between OSC and safety knowledge hypothesizing a full mediation of CSC and SSC on those relationships. The estimated model showed a great improvement of fit ($\chi2_{(2;\ N = 671)}$ = 12.84, p < .01, CFI = .99, RMSEA= .09, SRMR = .02). All paths estimates were statistically significant except the links that connected CSC and SSC to safety knowledge. The accounted variability in safety behaviours increased to 63%. On the basis of these results the model was retained to conduct multilevel path analysis. The multilevel model is presented in Figure 5 with the part of the model above the dashed indicating the within-group structure and that below the line representing between-group structure. The multilevel path analysis was conducted stating from the estimate of the within-group structural model. This estimate was conducted allowing the constructs freely covary at the group level. The fit for the within-group structural model were moderately good ($\chi2_{(17;\ N = 671)}$ = 174.54 , p < .001, CFI = .92, RMSEA= .12, $SRMR_{within}$ = .03, $SRMR_{between}$ = .57). All the path estimates were statistically significant except that one of the link between SSC and safety behaviours. Then, the multilevel path model was analysed estimating simultaneously within-group and between-group path models. The model showed good fit indices ($\chi2_{(4;\ N = 671)}$ = 21.84 , p < .001, CFI = .99, RMSEA= .08, $SRMR_{within}$ = .03, $SRMR_{between}$ = .07). The accounted variations in supervisor's safety climate and in co-workers' safety climate were at individual level 44% and 31%, and at group-level %83 and %87 respectively. Inspection of path estimates at within-group level indicated strong relationships between OSC and SSC (β = .67 p < .001), moderate relationships between SSC and CSC (β = .39 p < .001), between safety motivation and safety knowledge (β = .43 p < .001) and between safety knowledge and safety behaviours (β = .48 p < .001) and not statically significant coefficients for the link between CSC and safety knowledge and between SSC and safety behaviours. At between-group level only the relationships between OSC and SSC ($\beta = .91$ $p < .001$) and between safety motivation and safety behaviours ($\beta = .74$ $p < .01$) were statistically significant (see Figure 5). The accounted variations in safety motivation, safety knowledge and safety behaviours were at individual level 7%, 25% and 61%, and at group-level 37%, 63% and 98% respectively.

Standardized total indirect effects between safety climate variables and safety behaviours were calculated to assess the mediational role of safety determinants. At the individual level the standardized total indirect effect from OSC, SSC and CSC to safety behaviours were statistically significant (from OSC: $\beta = .22$ $p <.001$, CI = .11, .33; from SSC: $\beta = .23$ $p <.001$, CI = .13, .32; from CSC: $\beta = .13$ $p <.01$, CI = .02, .24). The relationships from OSC and CSC to safety behaviours were partially mediated because of the the statistically significant coefficient of the direct path between safety climate variables and safety behaviours. On the other hand the relationship between SSC and safety behaviours was fully mediated.

Finally, we tested the model adding the relationship between safety behaviours and safety outcomes (micro-accidents and injuries), adding one a time the links from safety behaviours to micro-accidents and to injuries. In both cases, the relationship was not statistically significant at individual level, but statistically significant at group level (for micro-accident: $\beta = -88.$ $p <.001$; for injuries: $\beta = -.96$ $p <.05$). For micro-accident model, at group level also the relationships between motivation and safety behaviours and between OSC and SSC were statically significant ($\beta = .62$ $p <.01$ and $\beta = .95$ $p <.001$, respectively). At the same level, for injuries model only the relationship between OSC and SSC was statically significant ($\beta = .94$ $p <.001$). In both cases fit indexes were similar to those of the previous model (for micro-accident: $\chi2_{(14;\ N\ =\ 671)} = 65.72$, $p < .001$, CFI = .97, RMSEA= .08, $SRMR_{within}$ = .03,

$SRMR_{between}$ = .08; for injuries: $\chi2_{(14;\ N\ =\ 671)}$ = 40.03 , p < .001, CFI = .99, RMSEA= .05, $SRMR_{within}$ = .04, $SRMR_{between}$ = .17). At group level the accounted variability for micro-accident was 78% and for injuries was 92%.

Discussion and future directions

The main goal of the present study is to integrate the framework of safety climates identified in the previous chapter with Griffin & Neal model, and with the later specification of the same model by Christian et al. (2009). The resulting model was assessed with multilevel techniques to properly analyse data that had multilevel nature, and to understand better the mechanisms that link antecedents, determinants and components of safety performance, at individual and at group level. To our knowledge, no research has, so far, tested this model with multilevel structural equation modelling analysis, hence we hope to have offered a contribute to promote this kind of multilevel integrated approach on the study of the relationships between safety climate, safety performance and safety outcomes, given the nested structure of the data.

In the process of analysis some important results came out. For instance, when we tested Griffin & Neal model, the path estimates from our data were very close to those of Griffin & Neal final model. This result is very interesting because it confirms the goodness of the proposed conceptual framework of workplace safety. When integrating the model with the system of safety climates, there was an improvement of the fit and a growth of the accounted variability of participation safety motivation and safety participation. This finding confirmed the important role of safety climate in increasing extra-role behaviours, as suggested in literature.

Another interesting result regarded the insertion of safety outcomes (injuries and micro-accidents) in the model. Only the relationship between safety compliance and micro-accidents was statistically significant. By a methodological point of view, this finding acknowledges the usefulness of considering micro-accidents instead of other safety criteria (accidents, injuries). As suggest by Zohar (2000, 2002) the use of micro-accidents has some methodological advantages: for instance, they happen much more frequently than injuries, resulting in a homogeneous distribution as a function of time.

A review of the multilevel path model at the individual level confirmed the mediating role of safety performance determinants in the relationship between safety climates system and safety performance.

The examination of the model considering the variability between groups confirmed the strong relationship between OSC and SSC, already found in literature (e.g. Zohar & Luria, 2005). Other relationships, which resulted not statistically significant, need to be treated with caution because of the limited size of the sample compared to the complexity of the model. The non-significant relationships at group level might be also attributed to the interactions of CSC and SSC. In future research, lateral relationships of SSC and CSC should be more deeply explored, to better understand the kind of reciprocal influences (e.g. additive, interactive, or compensatory) between these constructs.

This study has limitations that should be taken into account when interpreting the results, and future research is needed to address these limitations. First, the use of self-report measures is a clear limitation because in this way the estimates of the relationships between the measures may be confounded by common method variance. Second, objective measurement of safety behaviours and safety outcomes is needed to assess more properly the relationship between safety climate integrated system and safety performance, and between safety performance and safety outcomes.

Another limit was the small number of involved organizations, which did not permit to study organizational safety climate at a proper level. In addition the sample size at the group level and the complexity of the model did not permit to specify random slope to assess cross-level interactions.

Furthermore, recent works suggest that it is important to study climate considering not only climate level but also the strength of the climate, and that relationships between climate and outcomes are generally greater within strong climate. In the present work, we chose to consider only groups which had quite strong climate to analyse the model, so that the presence of a weak climate should not disturb the analysis of the relationships. In future researches it would be interesting to consider the potential moderating role of climate strength to understand deeply the dynamics among safety climates, and between the integrated system and safety behaviours. In future the influence of other variables related to the social context should also be investigated. For instance, the increasing presence of foreign workers in the organizations required to take into account the multicultural dimension of the workplace, and its influence on the relationship between safety climate and safety performance. There are few studies considering the association between these two aspects, for example, Schubert and Dijkstra (2009) argue that cultural differences lead to a different approach to safety rules and a different risk acceptance. This aspect can be well explained by reference to the theory of cultural differences of Hofstede (1991), one of the father of contemporary culture research.

In conclusion, the present study could be considered as one of the first contributions investigating a global and integrated framework on the influence of safety climate, as a system of safety agents' climates, on safety performance with multilevel structural equation modelling analyses. We hope that it can be the starting point for developing a more integrated and proper approach in safety climate research.

Table 4.1.
Characteristics of the Companies

Company	Products	Company size	Work-groups	Participants	% of Participants on the total number of the blue-collars	Micro-accidents in the last 6 months	Injuries in the company
1	refrigerating systems	medium	13	90	90%	34%	40%
2	refrigerating systems	large	41	432	79%	13%	59%
3	high and low voltage products and systems	medium	14	104	75%	12%	33%
4	Heat transfer solutions	small	6	49	82%	14%	38%
5	Electric motors and gearmotors	small	7	39	95%	11%	16%
Tot.			*81*	*714*	*84%*	*17%*	*37%*

Table 4.2
Characteristics of the Participants

Variables		N	%
Gender	male	567	79.7%
	female	144	20.3%
Age	18-25	61	8.7%
	26-35	146	20.7%
	36-45	248	35.2%
	46-55	199	28.2%
	> 55	51	7.2%
Nationality	Italian	666	93.4%
	foreign	39	5.6%
Educational level	< 5 y	23	3.3%
	5 – 8 y	351	49.8%
	9 – 13 y	285	40.4%
	> 13 y	46	6.5%
Years of work experience in the company	< 1 y	47	6.6%
	1- 5- y	161	22.8%
	> 5 y	510	70.6%
Injuries involvements in the company in the last 2 years	none	360	50.8%
	one	162	22.9%
	more than one	187	27.3%
Micro-accidents in the last 6 months	none	657	84.3%
	one	60	8.5%
	more than one	52	7.3%

Table 4.3
Results from Analysis on Between-group Variability

Construct	F	Degree of fredom	*p*	ICC
Organizational Safety Climate (OSC)	4.78	62	< .001	.28
Supervisor's Safety Climate (SSC)	3.98	62	< .001	.23
Co-workers' Safety Climate (CSC)	2.22	62	< .001	.12
Safety Motivation	4.13	62	< .001	.05
Safety Knowledge	3.67	62	< .001	.03
Safety Behaviours	1.85	62	< .001	.09
Safety compliance	1.87	62	< .001	.10
Safety participation	1.60	62	< .01	.07

Table 4.4
Descriptive Statistics for Study Variables

Construct	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
OSC	3.66 (3.68)	1.24 (.82)	1	.96**	.95**	.97**	.96**	.82**	.82**	.77**	.73**	.58**	.72**	.69**	.71**	.32**	.39**	.38**	.37**	.62**	.50**	.62**
OSC. S. Co.	3.49 (3.49)	1.32 (.79)	.89	1	.88**	.89**	.91**	.80**	.79**	.75**	.73**	.59**	.73**	.71**	.67**	.31*	.35**	.34**	.32*	.60**	.47**	.60**
OSC. S. Tr.	3.87 (3.89)	1.45 (.91)	.91	.75	1	.89**	.86**	.77**	.78**	.72**	.64**	.51**	.65**	.58**	.62**	.40**	.39**	.38**	.37**	.57**	.42**	.59**
OSC. S. Sys.	3.97 (3.99)	1.35 (.88)	.91	.73	.77	1	.93**	.77**	.78**	.72**	.69**	.53**	.67**	.68**	.69**	.29*	.41**	.38**	.40**	.61**	.54**	.56**
OSC. S. Val.	3.30 (3.36)	1.36 (.83)	.91	.74	.75	.79	1	.82**	.80**	.78**	.76**	.61**	.75**	.71**	.75**	.25*	.36**	.37**	.33**	.63**	.50**	.61**
SSC	3.46(3.52)	1.55(.92)	.73	.62	.66	.64	.69	1	.98**	.96**	.69**	.61**	.65**	.67**	.61**	.26*	.32**	.34**	.28*	.61**	.51**	.58**
SSC. React.	3.68 (3.72)	1.62 (.94)	.71	.62	.63	.62	.68	.94	1	.90**	.64**	.56**	.60**	.66**	.60**	.28*	.35**	.38**	.30*	.63**	.56**	.57**
SSC. Effort	3.12 (3.22)	1.59 (.97)	.69	.59	.64	.62	.66	.98	.84	1	.71**	.66**	.68**	.66**	.59**	21	.26*	.27*	.24	.55**	.42**	.56**
CSC	3.23(3.30)	1.34 (.64)	.54	.49	.47	.48	.51	.57	.56	.55	1	.91**	.97**	.92**	.91**	.62	.26*	.51	.29*	.51**	.28*	.62**
CSC. S. Co.	3.20 (3.24)	1.38 (.61)	.38	.36	.34	.33	.36	.44	.44	.41	.89	1	.84**	.80**	.74**	.23	.27*	.47	.30*	.47**	.21	.59**
CSC. S. Tr.	3.22 (3.32)	1.59 (.77)	.53	.49	.47	.46	.51	.54	.54	.50	.93	.74	1	.87**	.88**	.11	.24	.21	.24	.48**	.24	.60**
CSC. S. Sys.	3.04 (3.12)	1.48 (.68)	.48	.45	.41	.43	.46	.52	.48	.51	.89	.75	.80	1	.80**	.06	.26*	.19	.27*	.45**	.27*	.52**
CSC. S. Val.	3.50 (3.56)	1.49 (.69)	.54	.47	.48	.52	.50	.56	.52	.55	.87	.69	.77	.74	1	.05	.32	.19	.22	.49**	.32*	.55**
S. Know.	5.18 (5.16)	.94 (.37)	.28	.25	.29	.24	.23	.25	.25	.24	.24	.21	.22	.17	.25	1	.55**	.56**	.50**	.61**	.57**	.53**
S. Mot.	5.82 (5.79)	.85 (.39)	.27	.22	.24	.29	.20	.23	.21	.23	.26	.24	.21	.22	.24	.48	1	.94**	.97**	.71**	.66**	.62**
C. S. Mot.	5.97 (5.94)	.92 (.40)	.25	.22	.24	.28	.17	.19	.17	.19	.20	.18	.16	.17	.21	.46	.89	1	.82**	.70**	.68**	.59**
P. S. Mot.	5.70 (5.68)	.93 (.42)	.23	.19	.21	.25	.19	.23	.22	.22	.26	.25	.22	.22	.23	.42	.94	.68	1	.66**	.59**	.59**
S. Beh.	4.97 (4.95)	.85 (.44)	.45	.39	.40	.42	.40	.40	.40	.38	.43	.39	.39	.34	.40	.68	.60	.56	.55	1	.88**	.91**
S. Compl.	5.37 (5.33)	.95 (.46)	.37	.32	.34	.35	.32	.31	.29	.31	.28	.24	.24	.23	.30	.61	.53	.57	.42	.84	1	.61**
S. Particip.	4.57 (4.56)	1.13 (.51)	.40	.35	.36	.37	.37	.38	.40	.35	.45	.43	.42	.35	.38	.57	.51	.41	.52	.89	.51	1

Note. Means and standard deviations without parentheses are based on individual-level data (N = 671) and means and standard deviations in parentheses are based on group-level data (N = 62). Correlations below the diagonal are based on individual-level data and correlations above the diagonal are based on group-level data. All individual-level correlations are significant at **. * $p < .05.$, ** $p < .01$. *** $p < .001$.

Table 4.5
Fit Indexes for Measurement and Structural Models

Model	χ^2 (df)	*p*	CFI	TLI	RMSEA	SRMR/ $SRMR_w$	$SRMR_b$
.Measurement Model (Griffin & Neal)	1360.78 (476)	< .001	.91	.90	.06	.05	-
SEM - Model (Griffin & Neal)	1398.95 (479)	< .001	.91	.90	.06	.06	-
SEM - Model with Direct Path (Griffin & Neal)	1371.49 (477)	< .001	.91	.90	.06	.05	-
Measurement Model – Integrated M.	1223.94 (406)	< .001	.92	.91	.06	.05	-
SEM - Integrated M.	1277.37 (413)	< .001	.92	.91	.06	.06	-
SEM - Integrated M. with Micro-accident	1310.74 (442)	< .001	.92	.91	.06	.05	-
SEM - Integrated M. with Injuries	1360.17 (442)	< .001	.91	.90	.06	.06	-
Path. – Christian et al. Model	77.69 (1)	< .001	.91	.47	.34	.06	-
Path. – Christian et al. Model Integrated	108.65 (3)	< .001	.94	.65	.23	.06	-
Path. – Christian et al. Model Integrated with Direct Paths	12.84 (2)	< .001	.99	.95	.09	.02	-
Multilevel Path. - Within Model	174.54 (17)	< .001	.92	.85	.12	.03	.57
Final Multilevel Path. Model	21.84 (4)	< .001	.99	.93	.08	.03	.07
Final Multilevel Path. Model with Micro-accident	65.72 (14)	< .001	.97	.92	.08	.03	.08
Final Multilevel Path. Model with Injuries	40.30 (14)	< .001	.99	.96	.05	.04	.17

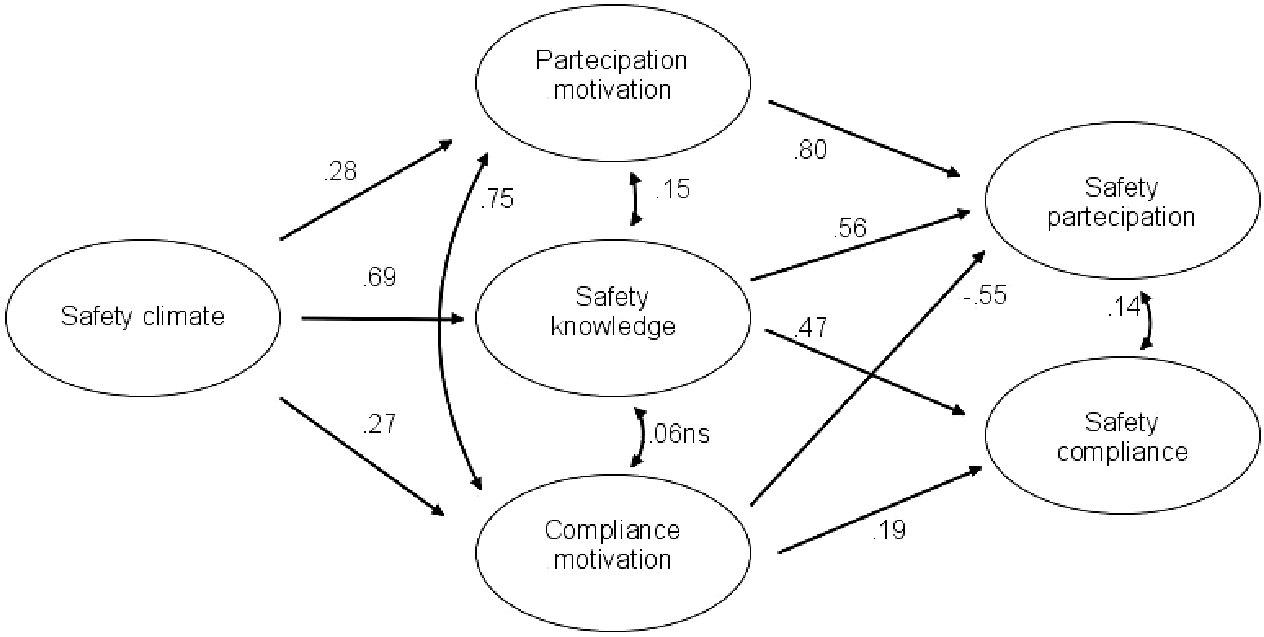

Figure 4.1. Path estimates of Griffin & Neal Model (2000)

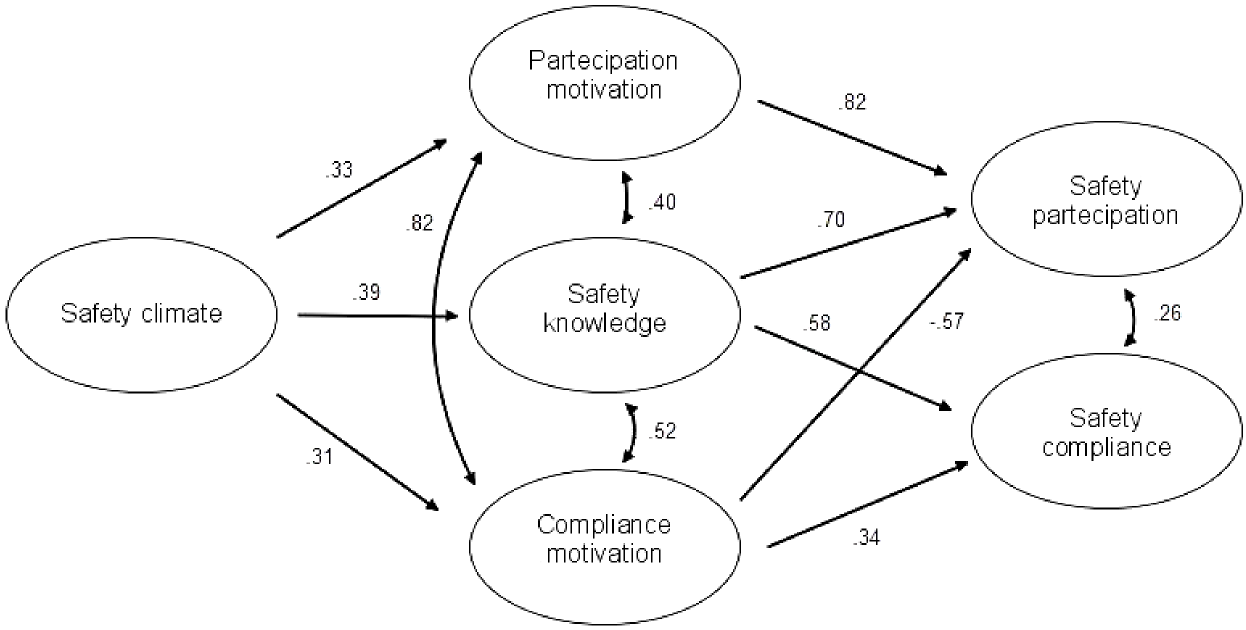

Figure 4.2. Path estimates of Griffin & Neal Model (2000) on the present sample

Note: All path estimates are significant at ***. * $p < .05$., ** $p < .01$. *** $p < .001$.

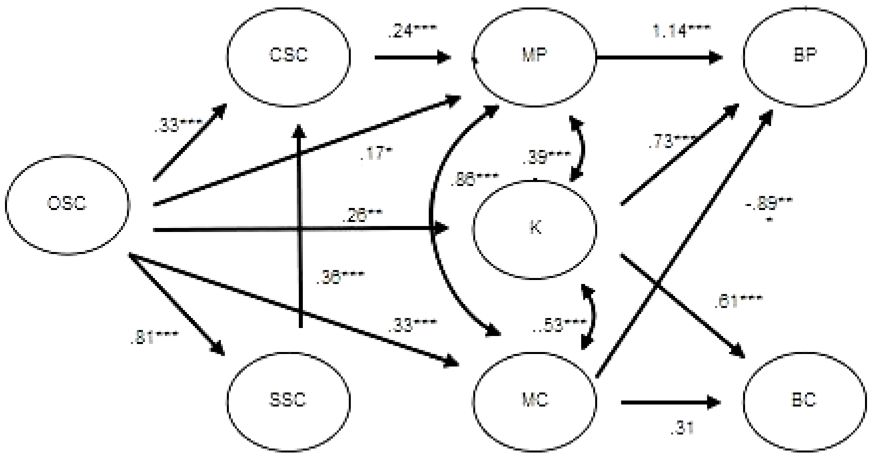

Figure 4.3. Path estimates of the integration model

Note: To simplify the graphic does not show the paths with non statistically significant estimates. * p < .05., ** p < .01. *** p < .001. MP = motivation to participate; K= knowledge; MC = motivation to compliance; BP = participation behaviours; BC = compliance behaviours.

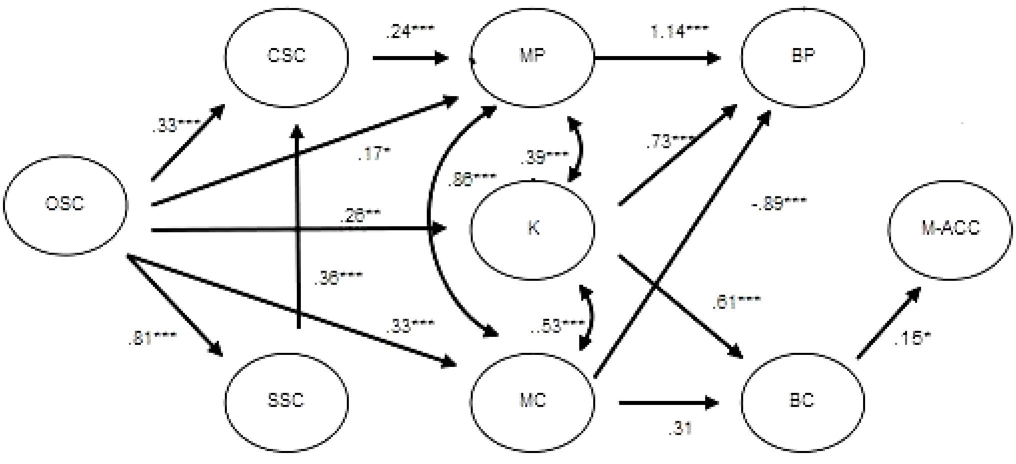

Figure 4.4. Path estimates of the integration model with micro-accidents

Note: To simplify the graphic does not show the paths with non statistically significant estimates. * p < .05., ** p < .01. *** p < .001. MP = motivation to participate; K= knowledge; MC = motivation to compliance; BP = participation behaviours; BC = compliance behaviours; M-ACC = micro-accidents.

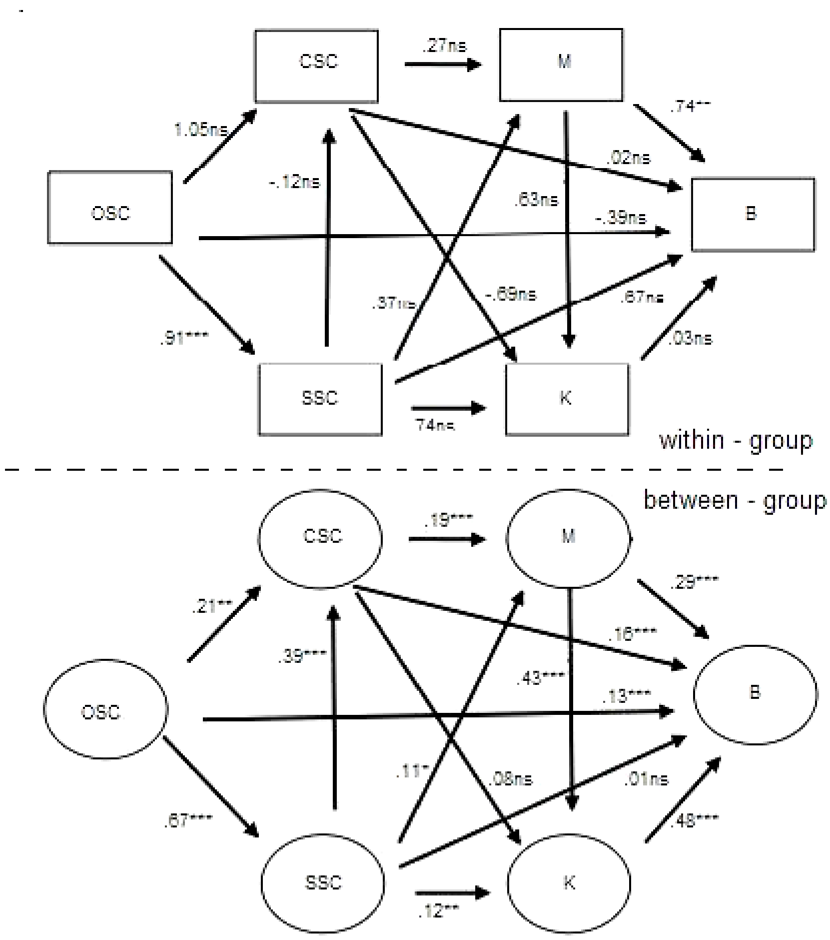

Figure 4.5. Path estimates of the multilevel model

Note: * $p < .05$., ** $p < .01$. *** $p < .001$. M = motivation; K= knowledge; B = behaviours

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Capitolo 5

Conclusioni

A conclusione di questo lavoro viene offerta una sintesi di quanto emerso dai singoli studi delineando il contributo che questi portano alla ricerca sul clima di sicurezza come leading indicator della performance di sicurezza, i limiti che si sono riscontrati nel percorso e possibili aspetti che potrebbero essere approfonditi in studi futuri.

Il clima di sicurezza viene ormai unanimemente considerato un importante costrutto in riferimento alla gestione della dimensione soggettiva della sicurezza nei luoghi di lavoro perché ha un impatto di rilievo sugli atteggiamenti e sui comportamenti dei lavoratori, nonché sugli incidenti (e.g. Christian, Bradley, Wallace, & Burke, 2009; Zohar, 2010a; Beus, Payne, Bergman & Arthur, 2010). Nel presente lavoro viene definito come l'insieme delle percezioni dei lavoratori riguardo alle politiche, alle procedure e alle pratiche relative alla sicurezza. In particolare le politiche e le procedure sono riferite al management, mentre le pratiche sono riferite ai preposti e ai colleghi di lavoro. La peculiarità di questa definizione declinata in base agli agenti di clima riflette il tentativo di offrire un contributo rispetto alle questioni ancora aperte in merito alla ricerca sul clima di sicurezza, integrando gli esiti del lavoro condotto in particolare da alcuni studiosi di clima quali Melià (e.g. Melià, 1998, 2002, 2004; Melia & Becerill, 2006; Melià & Sesè, 2007; Melià, Mearns, Silva & Lima, 2008), Zohar (e.g. 1980, 2000, 2004, 2010b, 2010c; Zohar & Luria, 2005; Zohar & Tenne-Gazit, 2008; Zohar & Hofmann, 2010) e Griffin & Neal (e.g. Griffin & Neal, 2000; Neal & Griffin 2000, 2002, 2004, 2006; Neal, Griffin & Hart, 2000).

Rispetto agli studi di Melià, si è fatto riferimento in particolare al suo approccio al clima centrato sulle risposte ai lavoratori date da management, preposti e colleghi (Melià et al., 2008) riguardo alla sicurezza. Tale approccio bene si integra con gli studi di Zohar che, esplorando la natura multilivello del clima di sicurezza, mette al centro della valutazione di tale costrutto i soggetti che in quanto leader lo determinato, sia a livello organizzativo (il management) sia a livello di gruppo di lavoro (il preposto). Il considerare accanto a questi due agenti di clima il ruolo dei colleghi di lavoro permette non solo di studiare il clima in modo più articolato ed esaustivo, ma anche di poter indagare in modo più approfondito l'influenza che il clima riferito a ciascun agente ha rispetto agli altri climi, e in particolare, a livello di gruppo, di approfondire l'effetto delle relazioni laterali tra clima riferito al preposto e clima riferito ai colleghi. Questa ipotesi si fonda sull'evidenza empirica, riscontrata da molti studiosi, dell'opportunità di intervenire sul gruppo per migliorare la sicurezza nei luoghi di lavoro (e.g. Turner & Parker, 2004; Tesluk & Quigley, 2003; DeJoy, 1996; Hofmann, Jacobs & Landy, 1995) e dell'importanza dell'influenza del ruolo dei colleghi di lavoro sulla performance del singolo lavoratore (Chiaburu & Harrison, 2008). A tale proposito il presente lavoro conferma il valore predittivo del clima di sicurezza riferito ai colleghi di lavoro sulla performance di sicurezza, valore predittivo che nel secondo studio si rivela addirittura maggiore di quello del clima relativo al preposto. Inoltre, si evidenzia come il clima di sicurezza relativo ai colleghi abbia un ruolo di mediazione importante per le relazioni tra clima di sicurezza organizzativo e comportamenti di sicurezza, e tra clima di sicurezza riferito al preposto e comportamenti di sicurezza.

Gli studi di Zohar sono stati inoltre un importante riferimento nella costruzione del questionario per la misurazione del sistema integrato di climi e per la scelta delle tecniche di analisi da adottare. Egli, infatti, sottolinea come la natura multilivello del costrutto richieda tecniche adeguate per la validazione di strumenti per la misurazione del clima di sicurezza e per una appropriata analisi a più livelli delle relazioni tra questo costrutto e altre variabili (cfr. Shannon & Norman, 2009; Preacher, Zyphur & Zhang, 2010; Kozlowski & Klein, 2000).

Da questo punto di vista la presente ricerca si pone come uno dei primi, se non il primo tentativo di validazione di scale relative al clima di sicurezza tramite l'analisi fattoriale confermativa multilivello. L'applicazione di tale tecnica ha permesso di studiare la struttura fattoriale dei costrutti su due livelli, within e between, verificando non solo che a livelli diversi si riscontrano pesi fattoriali diversi ma anche come da livello a livello possa cambiare la struttura fattoriale del costrutto analizzato. Nel nostro studio, ad esempio, per la scala relativa al preposto e quella relativa ai colleghi di lavoro sono risultate maggiormente adeguate a livello within e between strutture fattoriali diverse. Nel complesso le strutture fattoriali proposte, per tutti e tre i climi, sono risultate appropriate; in particolar modo quelle individuate per le scale relative al preposto e ai colleghi di lavoro.

Nella definizione delle dimensioni dei costrutti di clima e della loro struttura fattoriale sono stati presi a riferimento gli studi condotti da Griffin e Neal (e.g. Griffin & Neal, 2000; Neal et al. 2000) a cui molti autori successivamente si sono ispirati (e.g. Zacharotos, Barling & Iverson, 2005; Probst & Estrada, 2010; Zohar, 2008; Dal Corso, 2008; Sinclair, Martin & Sears, 2010). Lo stesso Zohar (2010a) si riferisce alla struttura fattoriale proposta da questi autori – ovvero con un fattore di secondo ordine e più fattori di primo ordine – come probabilmente la più adeguata per la struttura del clima di sicurezza. Infatti, in questa struttura i fattori di primo ordine riflettono le percezioni dei lavoratori riguardo alle specifiche politiche, procedure e pratiche portate avanti in azienda in relazione alla sicurezza, mentre il fattore di secondo ordine riflette una percezione globale dei lavoratori rispetto al modo in cui la sicurezza è considerata all'interno dell'organizzazione in cui lavorano; considerando i tre tipi di clima, tale percezione globale si riferirà al management, al preposto, o ai colleghi di lavoro. Griffin e Neal (2000), riferendosi al clima organizzativo di sicurezza, identificano quattro fattori di primo ordine: i valori del management, che si riferiscono a quanta importanza realmente dà la direzione aziendale alla sicurezza; i sistemi di sicurezza, tesi a verificare le percezioni sull'efficacia della struttura sicurezza in azienda; la formazione alla sicurezza, che si riferisce alla qualità e quantità della formazione realizzata in azienda; la comunicazione sulla sicurezza, che riguarda i modi con cui le questioni relative alla sicurezza vengono comunicate.

In questa ricerca, nell'adottare tale struttura, i quattro fattori di primo ordine sono stati declinati in modo appropriato a seconda delle specificità di ciascuna scala. Nel complesso, il processo di sviluppo e validazione dello strumento attraverso utilizzo di tecniche sia qualitative, come ad esempio l'intervista cognitiva, sia quantitative, come l'analisi fattoriale confermativa multilivello, ha permesso di offrire un'efficace strumento diagnostico che nello stesso tempo dà la possibilità di valutare ciascun clima sia rispetto ad un fattore generale sia rispetto a fattori specifici di primo ordine. Attraverso il questionario proposto, infatti, è possibile studiare il clima declinato rispetto agli agenti di sicurezza, e quindi capire il diverso impatto che questi hanno nell'influenzare i comportamenti di sicurezza dei lavoratori. Mediante un'analisi del clima così strutturata è possibile quindi valutare su quali agenti di clima è necessario intervenire per avere una maggiore influenza sui comportamenti del singolo lavoratore. Inoltre, per ciascun clima è possibile verificare, grazie alle specifiche dimensioni (ad esempio commitment del management o mentoring dei colleghi di lavoro), in quali specifici aspetti vengono riscontrate criticità da parte dei lavoratori e quindi rispetto a cosa intervenire in modo appropriato.

Inoltre gli studi di Neal e Griffin, ma anche quelli successivi di Christian e colleghi (2009), hanno offerto un utile framework per studiare la relazione tra clima di sicurezza e performance di sicurezza, considerando sia le componenti (compliance e participation), che le determinanti (motivazione e conoscenze rispetto alla sicurezza) di quest'ultima. A tale proposito sia nel secondo che nel terzo studio i modelli proposti da Griffin e Neal (2000), e successivamente da Christian e colleghi (2009), vengono confermati attraverso l'analisi con i modelli di equazioni strutturali, sia considerando il clima psicologico, sia con modelli multilivello. Ancora una volta emerge come il clima di sicurezza predica non solo la performance di sicurezza, ma, attraverso quest'ultima, anche gli outcome di sicurezza come ad esempio i microincidenti (cfr. Beus et al, 2010; Christian et al., 2009; Nahrgang, Morgenson & Hofmann, 2007, Clarke, 2006).

I risultati dell'analisi con i modelli di equazioni strutturali multilivello evidenziano la bontà del modello proposto anche dopo aver inserito il sistema integrato di climi. L'integrazione aumenta la capacità predittiva del modello. Nel secondo studio inoltre sia a livello individuale che a livello di gruppo va sottolineata l'importanza che risulta avere il ruolo del clima di sicurezza nell'influenzare la partecipazione volontaria ad attività che promuovano la sicurezza nell'organizzazione (cfr. Christian et al., 2009).

Sempre ad entrambi i livelli, emerge ancora una volta la forte influenza del clima di sicurezza relativo ai colleghi sui comportamenti di sicurezza dei lavoratori. La capacità predittiva del clima di sicurezza dei colleghi, sia nel secondo che nel terzo studio, risulta più alta di quella relativa al clima riferito al preposto, evidenziando l'importanza del ruolo colleghi di lavoro nel determinare i comportamenti dei singoli. Questo risultato è coerente con quanto affermato dalla teoria dell'interdipendenza di Kelley e Thibaut (1978), e con i risultati di molti studi precedenti, come ad esempio quelli emersi dall'analisi meta-analitica condotta da Chiaburu e Harrison (2008). Tale rilevanza del clima riferito ai colleghi, accanto alla inattesa debolezza del ruolo del clima riferito al preposto, suggerisce come in future ricerche potrebbe essere interessante esplorare maggiormente l'interazione tra i climi relativi a questi due agenti, per valutare all'interno del gruppo di lavoro che tipo di reciproca influenza (ad esempio additiva o compensativa) hanno queste relazioni laterali.

Nel terzo studio viene confermato il ruolo di mediazione delle determinanti di sicurezza a livello individuale, mentre a livello di gruppo emerge nuovamente il legame tra comportamenti di sicurezza e outcome di sicurezza (infortuni e microincidenti). Tuttavia la non significatività degli altri legami va considerata con cautela a causa del numero limitato di gruppi di lavoro rispetto alla complessità del modello (cfr. Muthén & Asparouhov, 2009).

Altri limiti della ricerca sono, ad esempio, l'impossibilità di analizzare il clima di sicurezza organizzativo considerando anche il livello organizzativo come un terzo livello, oltre a quello di gruppo e a quello individuale, a causa del limitato numero di aziende che fanno parte del campione, o il fatto che gli studi proposti utilizzino dati self-report per tutte le variabili in esame, poiché in questo modo le stime delle relazioni tra misure possono essere distorte a causa della varianza comune presente tra costrutti diversi misurati con lo stesso metodo.

Tuttavia, nonostante i limiti, questa ricerca costituisce a nostro parere un contributo significativo, sia dal punto di vista teorico sia dal punto di vista metodologico, che apre la strada per ulteriori approfondimenti. Tra questi, possono esserne sottolineati alcuni, quali ad esempio l'approfondimento degli studi sul clima di sicurezza concepito come un sistema integrato di climi basato sulle figure degli agenti che determinano la sicurezza in azienda; l'uso di tecniche adeguate alla natura multilivello del costrutto di clima di sicurezza per verificare l'adeguatezza di modellizzazioni ad esso riferite; la verifica della relazione tra il sistema integrato di climi e altre variabili, sia che si tratti di possibili antecedenti del clima, sia che si pensi a possibili moderatori nella relazione tra clima e performance; l'approfondire il ruolo del clima non solo come *leading indicator*, ma anche come *lagging indicator* della performance di sicurezza attraverso studi longitudinali (cfr. Neal & Griffin, 2006; Payne, Bergman, Beus a, Rodrıguez & Henning, 2009).

Inoltre, data la sempre più rilevante presenza di contesti lavorativi multiculturali, di particolare interesse potrebbe essere anche l'approfondimento di come tale realtà influisce nei processi di generazione del clima, e di come essa vada considerata nell'analisi del clima di sicurezza. Infatti, alcuni studiosi (e.g. Schubert and Dijkstra, 2009), sulla base dei principi della teoria delle differenze culturali (Hofstede, 1991) hanno verificato come le differenze culturali influiscono sui comportamenti di sicurezza dei lavoratori o sulla loro percezione del rischio.

Infine si spera che il questionario elaborato in questa ricerca per l'analisi del clima di sicurezza in contesto industriale, e in particolare tra i lavoratori impegnati in reparti produttivi, diventi uno strumento per promuovere maggiormente nel contesto industriale italiano l'analisi e il monitoraggio del clima di sicurezza come leva importante nell'attività di prevenzione e gestione della sicurezza in azienda.

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