Istituti Clinici Scientifici Maugeri IRCCS

GIORNALE ITALIANO DI MEDICINA DEL LAVORO ED ERGONOMIA

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di Antonio Mutti e Massimo Corradi

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"Ci auguriamo che questo nuovo testo, più snello, possa incontrare lo stesso favore della prima edizione. In questa nuova edizione, per oggettività, non abbiamo abbandonato la trattazione di temi classici, come l'intossicazione da mercurio, da piombo e da cadmio e alcune pneumoconiosi, perché sono un patrimonio di conoscenze accumulate in un secolo di vita accademica della disciplina nelle università italiane e perché quadri clinici ritenuti ormai obsoleti si possono sempre riproporre, magari in contesti extra-lavorativi inusuali e inaspettabili, come l'intossicazione da piombo per l'utilizzo di ceramiche artigianali nella preparazione e cottura di alimenti o come quadri di silicosi in fabbriche di pasta." – *Gli Autori*

Questa nuova edizione delle *Lezioni di Medicina del Lavoro* comprende alcuni aspetti della disciplina tralasciati nella prima edizione, otto anni fa ritenuti ancora "emergenti", come i fattori psico-sociali ed altre problematiche, che oggi invece sono diventate prevalenti nell'attività quotidiana dei medici del lavoro impegnati nel mondo produttivo e identificati dalla normativa vigente come medici competenti. L'impianto del libro rimane comunque articolato in molte aree classiche, come Igiene Industriale, Ergonomia, Tossicologia, Epidemiologia e le malattie trattate da settori specialistici della Medicina, ma classificate come "occupazionali" o "professionali" – ad esempio, le Broncopneumopatie, le Neuropatie e le altre patologie d'organo, oltre ad alcuni capitoli sulla promozione della salute.

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GIORNALE ITALIANO DI MEDICINA DEL LAVORO ED ERGONOMIA

Rivista di **Medicina del Lavoro** (Medicina Occupazionale e Ambientale, Igiene del Lavoro, Tossicologia Occupazionale) ed **Ergonomia** (Rapporto Uomo/Lavoro, Riabilitazione Occupazionale, Terapia Occupazionale, Psicologia del Lavoro, Ergonomia)

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MEDICINA DEL LAVORO

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Un sistema per la catalogazione delle Esposizioni Storiche Professionali negli Ambienti di Lavoro in Piemonte (ESP ALP)

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RIASSUNTO. ***Introduzione.*** **ARPA Piemonte effettua misure di esposizione professionale ad agenti chimici nelle aziende piemontesi a supporto dei Servizi per la Prevenzione e la Salute negli Ambienti di Lavoro (SPreSAL) dei Dipartimenti di Prevenzione delle Aziende Sanitarie Locali. Le attività svolte riguardano la valutazione dei livelli di esposizione ad agenti chimici pericolosi e originano la redazione di rapporti ad uso interno ma non costituiscono un patrimonio informativo condiviso e accessibile per altri scopi.**
Obiettivi. **Organizzare e strutturare le misure di esposizione professionale raccolte da ARPA Piemonte, anche allo scopo di facilitarne l'accesso e l'utilizzo, conformemente alle indicazioni provenienti dalla European Foundation for the Improvement of Living and Working Conditions.**
Metodi. **È stata definita e sviluppata un'applicazione in ambiente di database relazionale per raccogliere e strutturare informazioni relative alle ditte, agli interventi, alle mansioni e/o punti di prelievo monitorati, ai campioni e alle misure effettuate.**
Risultati. **Sono state riversate e validate nell'applicazione ESP ALP (Esposizioni Storiche Professionali negli Ambienti di Lavoro in Piemonte) le informazioni degli interventi effettuati da ARPA Piemonte dal 2005 al 2020, relativamente a 161 ditte, 193 interventi, 815 mansioni / punti di prelievo, 3.490 campioni e 18.576 misure. Le informazioni raccolte sono state arricchite attraverso l'integrazione con il Censimento delle Attività Economiche 2011 e gli archivi delle ditte assicurate all'INAIL.**
Discussione. **È stata verificata la fattibilità del recupero e dell'organizzazione delle informazioni raccolte negli anni passati in un ambiente integrato che ne faciliti il trattamento e l'utilizzo. È stata infine confermata l'utilità della collaborazione fra operatori di diverse strutture e professionalità.**

Parole chiave: Igiene industriale, Misure di esposizione, Integrazione sistemi informativi.

ABSTRACT. A SYSTEM FOR COLLECTING HISTORICAL PROFESSIONAL EXPOSURES IN THE WORKPLACE IN PIEDMONT (ESP ALP).
Background. ***ARPA Piemonte carries out occupational exposure measurements of chemical agents in workplace environment to support the Occupatonal Health and Safety Units of Local Health Boards for the assessment of the exposure level of dangerous chemical. Data are reported in internal documents, but are not available for other purposes.***
Objectives. ***Organize the occupational exposure measures collected by ARPA Piemonte, in order to facilitate their availability, in accordance with the indications of the European Foundation for the Improvement of Living and Working Conditions.***

Introduzione

Da quasi trent'anni ARPA Piemonte effettua interventi di monitoraggio di agenti chimici pericolosi nelle aziende piemontesi principalmente a supporto e in collaborazione con la rete dei Servizi di Prevenzione e Salute negli Ambienti di Lavoro (SPreSAL) delle ASL piemontesi.

I fascicoli relativi agli interventi effettuati sono conservati, in formato cartaceo ed elettronico, presso gli archivi di ARPA Piemonte ma sono difficilmente consultabili e riutilizzabili a livello aggregato.

Si è ritenuto necessario rendere fruibili i dati di esposizione acquisiti e facilitare l'accesso e la consultazione del materiale prodotto, allo scopo di diffondere la conoscenza delle valutazioni effettuate, suddivise per le principali dimensioni di interesse (tipologia e settore delle ditte, periodo temporale, agenti misurati).

L'attività di progettazione del contenuto informativo da trattare e strutturare è stata compiuta tenendo in considerazione le indicazioni provenienti dal Gruppo di Lavoro sui Registri di Esposizione in Europa promosso dalla European Foundation for the Improvement of Living and Working Conditions (1).

Nell'ambito dei lavori del Gruppo regionale piemontese sul rischio chimico è stata confermata l'opportunità di progettare e sviluppare un sistema per valorizzare e condividere i dati di esposizione professionale ad agenti chimici aerodispersi negli ambienti di lavoro, raccolti da ARPA Piemonte. Si è inoltre ritenuta utile un'attività di *data integration* allo scopo di associare alle ditte oggetto di intervento alcune informazioni, disponibili nel Sistema informativo regionale piemontese e di fonte Istat e INAIL, di classificazione dei settori di attività economica e del numero di addetti e di malattie professionali.

Una comunicazione preliminare degli obiettivi del sistema ESP ALP è stata inserita nel libro degli atti del Convegno nazionale Reach 2017 (2) nell'ambito della Convention Ambiente Lavoro svoltasi a Modena il 13-14 settembre 2017; un aggiornamento delle attività in corso è stato inoltre presentato nel workshop sui cancerogeni occupazionali all'interno del convegno CANCTUM 2020 svoltosi a Civitanova Marche il 19 febbraio 2020.

Methods. ***An application in a relational database environment was defined and developed to collect and structure information relating to companies, interventions, tasks and / or monitored sampling points, samples and measurements performed.***
Results. ***Data on chemical exposure related to interventions carried out by ARPA Piemonte in the period from 2005 to part of 2020 have been collected in the ESP ALP application. ESP ALP contains information about 161 companies, 193 interventions, 815 sampling points, 3.490 samples and 18.576 measurements and information on companies obtained from the 2011 Census of Economic Activities and the archives of the National Institute for Insurance against Accidents at Work (INAIL).***
Discussion. ***We verified the feasibility of retrieving and organizing the information collected in past years in an integrated environment that facilitates its processing and use. Finally, we confirm the usefulness of collaboration between multidisciplinary professionals.***

Key words: *Industrial hygiene, Exposure measures, Integration of information systems.*

Metodi

A seguito della definizione del contenuto informativo di cui prevedere il trattamento, è stato definito lo schema delle entità e relazioni e l'elenco delle singole variabili da trattare. Tale schema, riportato in Figura 1, è stato implementato in un ambiente di database relazionale, specificamente nelle versioni 2003 e quindi 2016 di Microsoft Access.

Sempre in ambiente Microsoft Access è stata quindi progettata e resa disponibile un'interfaccia utilizzabile per le attività di archiviazione delle misure effettuate denominata ESP ALP (Esposizioni Storiche Professionali negli Ambienti di Lavoro in Piemonte). La Figura 2 riporta due videate operative dell'applicazione sviluppata.

L'applicazione permette il trattamento e l'aggiornamento delle informazioni riguardanti:

- dati relativi alla ditta e all'intervento: ragione sociale, indirizzo, comune e provincia, settore di attività (non classificato), numero stimato di addetti, ente richiedente e anno di intervento;
- dati sulla mansione monitorata e/o punto di prelievo: denominazione reparto, lavorazione, mansione/posizione, aspirazioni localizzate (assenti - presenti), dettaglio aspirazioni (adeguate - inadeguate - non valutate), DPI utilizzati (DPI per le vie respiratorie - non presenti) e dettaglio DPI (adeguati - inadeguati - non valutati);
- dati sul campione di aeriformi: numero campione, data, tipo (ambientale - personale), durata prelievo, flusso di aspirazione, metodo di prelievo di riferimento, metodo di analisi e classe degli agenti ricercati;

Figura 1. ***Schema delle entità e delle relazioni trattate***

Figura 2. ***Videate operative per il trattamento delle variabili Mansione / posizione e Misura***

- dati sulla misura: denominazione sostanza, CAS, unità di misura e concentrazione rilevata.

Nell'applicazione non sono raccolte le misure relative ad agenti biologici e fisici, misure di ventilazione o dati ambientali di altro genere.

Risultati

Sono state riversate in ESP ALP le informazioni relative agli interventi effettuati da ARPA Piemonte dal 2005 al 30 aprile 2021; la validazione dei dati inseriti ha riguardato le misure acquisite al 31 dicembre 2020; il riepilogo delle informazioni raccolte è riportato in Tabella I.

Tabella I. ***Informazioni riversate nell'applicazione ESP ALP***

Entità	Numero osservazioni validate al 31/12/2020*	Dati inseriti al 30/04/2021
Ditte	161	178
Interventi	193	208
Mansioni/posizioni	815	904
Campioni	3.490 (di cui 1.950 di tipo personale e 1.540 di tipo ambientale)	3.990
Misure	18.576	18.662
Agenti con misure	220	249

* Le distribuzioni riportate nelle tabelle successive fanno riferimento a questi dati validati

Le informazioni raccolte sono state arricchite attraverso l'integrazione con:

- Censimento Istat delle attività economiche 2011 attive in regione Piemonte, associando a ogni unità locale il numero di addetti e il codice ATECO; il collegamento ha avuto successo per 147 ditte (144 individuate come unità locali delle imprese, 2 delle istituzioni e una delle imprese non profit) su 161, pari al 91,30% delle ditte considerate; alcune ditte non sono state individuate in quanto con sede fuori dal territorio regionale ed altre in quanto presumibilmente non attive alla data del censimento 2011; il numero di misure associate a ditte per cui il collegamento ha avuto successo è stato 17.323 (pari al 93,25% delle 18.576 misure totali);
- Archivi delle ditte assicurate all'INAIL, associando la Voce di Tariffa e il numero di addetti: il collegamento ha avuto successo per 118 ditte su 161, pari al 73,29% delle ditte considerate; il numero di misure associate a ditte per cui il collegamento ha avuto successo è stato 14.393 (pari al 77,48% delle 18.576 misure totali).

Utilizzando l'informazione sul codice ATECO di attività economica, tratto dal collegamento con il censimento 2011, è stato possibile associare alle misure la relativa classe ATECO; la distribuzione delle classi ricercate relativamente ad alcune divisioni della sezione ATECO C – Attività manifatturiere è riportata in Tabella II. In Tabella III è presente un'analoga distribuzione del numero di misure per classe ricercata e raggruppamento di Voci di Tariffa relative al comparto manifatturiero, ottenuta tramite il collegamento con gli archivi di fonte INAIL.

Nell'applicazione ESP ALP sono state predisposte le usuali operazioni di reporting di base a partire dalle variabili di classificazione e analisi disponibili. In particolare, sono state definite alcune funzioni di riepilogo, fra le quali:

- riepilogo 1: numero di misure per famiglia chimica/classe, agente ricercato, metodo di prelievo e di analisi e anno della misura (vedi Tabella IV con l'esempio delle misure riportate per una selezione di agenti);
- riepilogo 2: numero di misure per agente ricercato, CAS, denominazione agente, unità di misura e anno di acquisizione;
- riepilogo 3: numero di misure, valori riscontrati, CAS, denominazione agente e unità di misura;
- riepilogo 4: numero di misure per agente ricercato, CAS, denominazione agente, unità di misura e tipo della misura (ambientale/personale).

Ulteriori restituzioni possono essere definite utilizzando in questo caso le funzionalità di accesso a database Microsoft Access fornite dall'ambiente SAS System, riportando altri indicatori e restituzioni grafiche per ogni combinazione di classe ricercata e agente.

Discussione

La disponibilità dell'informazione sulle misure di esposizione è particolarmente importante in quanto può supportare attività relative concernenti almeno tre obiettivi:

- rendere disponibili e accessibili maggiori informazioni per la vigilanza da parte dei Servizi di Prevenzione negli Ambienti di Lavoro;
- fornire maggiori informazioni per i datori di lavoro ai fini della valutazione dei rischi ex Titolo IX Capo II del D.Lgs 81/2008;
- mettere a disposizione maggiori informazioni utili per le indagini sulle malattie professionali, permettendo l'accesso a misure di esposizione anche di anni non recenti per documentare il livello di esposizione dei lavoratori allo stato della tecnica in periodi passati.

Per consentire l'accesso e l'interrogazione del patrimonio informativo raccolto, è stata inoltre avviata la valutazione di utilizzo di una piattaforma basata sull'ambiente web.

Le attività finora svolte hanno attestato la fattibilità del recupero e dell'organizzazione delle informazioni raccolte negli anni passati dal personale di ARPA Piemonte in un ambiente omogeneo e integrato che ne faciliti il trattamento e l'utilizzo.

ESP ALP ha già dimostrato la sua utilità contribuendo a rispondere a una domanda, proveniente dal Gruppo Nazionale Cancerogeni nel marzo 2019, relativa all'individuazione delle attività produttive e delle mansioni per cui sono state valutate le esposizioni a silice libera cristallina e formaldeide. Il Gruppo Nazionale Cancerogeni sta infatti valutando la progettazione di un ambiente che raccolga e metta a sistema i dati delle misure di agenti cancerogeni effettuate in Italia da soggetti pubblici (ASL, ARPA, Laboratori) negli anni passati, con attenzione alle mansioni e in

Tabella II. ***Distribuzione del numero di misure in base alla classe ricercata e a una selezione delle divisioni di attività economica ATECO***

Classe ricercata	Divisioni della classificazione ATECO - Sezione C Attività manifatturiere									Totale
	10. Alimentari	13-14. Tessile e abbigliamento	17-18. Carta e stampa	19-22. Petrolio, chimica, gomma e plastica	23-25. Minerali non metalliferi, metallurgia e metallo	26-28. Elettronica, apparecchiature elettriche e macchinari	29-30. Autoveicoli e altri mezzi di trasporto	31. Mobili (in legno e metallo)	32. Altre manifatturiere	
Acidi Inorganici		18		60						78
Acido Acetico		3		27						30
Alcooli				10						10
Aldeidi	132	25	16	1.204	527	411	121		84	2.520
Ammine Aromatiche				56						56
Ammoniaca		5								5
Anidride Solforosa		12								12
Chetossime				10						10
Cromo Esavalente						7				7
Fenoli				8	17					25
Formaldeide nelle polveri				9			8			17
Fumi di Saldatura					26	18	27			71
Glicoli				18						18
Idrocarburi Policiclici Aromatici	143	44		1.735	1.918	170	74			4.084
Isocianati				76	20	20				116
Mercurio				22						22
Metalli	8			101	1.344	190	239	112		1.994
Monossido di Carbonio	8				13					21
Nebbie Oleose			8	14	91	27	14			154
Nero di Carbonio				8						8
Policlorobifenili e Diossine					63					63
Polveri Inalabili	16	43	7	112	160	19	36	7	15	415
Polveri Respirabili	3	26	7	56	197	4		7		300
Polveri di Farina	24									24
Polveri inalabili	10									10
Silice Libera Cristallina				7	128					135
Solfuro di Carbonio		6		16						22
Sostanze Organiche Alogenate			1	291	74					366
Sostanze Organiche Volatili		45	1.074	2.175	1.090	136	506		143	5.169
Totale	344	227	1.113	6.015	5.668	1.002	1.025	126	242	15.762

differenti contesti produttivi. Le Tabelle V e VI fornite da ARPA Piemonte al Gruppo Nazionale Cancerogeni rappresentano due esempi di restituzioni di ESP ALP che evidenziano con un buon livello di dettaglio i settori produttivi, le mansioni coinvolte, i metodi analitici utilizzati e le concentrazioni riscontrate delle due sostanze cancerogene (silice libera cristallina e formaldeide) in un arco temporale sufficientemente lungo da essere considerato rappresentativo della situazione produttiva piemontese.

Le stesse misure di concentrazione di sostanze chimiche negli ambienti di lavoro consentono di confrontare i livelli medi realmente misurati con i valori limite di esposizione occupazionale suggeriti dalle istituzioni internazionali (3) o imposti dalla normativa vigente.

In generale, si è confermato che ESP ALP rappresenta uno strumento adeguato per organizzare in modo organico le informazioni sull'esposizione professionale ad agenti chimici nelle aziende piemontesi. La possibilità di accedere

Tabella III. ***Distribuzione del numero di misure in base alla classe ricercata e a una selezione delle voci di tariffa della classificazione INAIL***

Classe ricercata	Raggruppamento delle voci di tariffa INAIL del comparto manifatturiero									Totale
	21. Chimica, materie platiche e gomma	22. Carta e poligrafia	52. Mobili (in legno)	6. Metallurgia e metalmeccanica	64. Mezzi di trasporto	65. Strumenti e apparecchi	7. Mineraria e materiali non metalliferi	73. Vetro	8. Tessile e abbigliamento	
Acidi Inorganici	44			16					18	78
Acido Acetico	15								3	18
Aldeidi	960	16		987	21	86	10		35	2115
Ammine Aromatiche	50									50
Ammoniaca									5	5
Anidride Solforosa									12	12
Biossido di Azoto e di Zolfo										0
Cromo Esavalente				7						7
Fenoli	8			17						25
Formaldeide nelle polveri	9					8				17
Fumi di Saldatura				11	45					56
Idrocarburi Policiclici Aromatici	1.689			2.016		38			44	3.787
Isocianati	96			20						116
Mercurio	22									22
Metalli	103			1.044	266	113	1			1.527
Monossido di Carbonio				13						13
Nebbie Oleose	14	8		118	8					148
Nero di Carbonio	8									8
Policlorobifenili e Diossine				63						63
Polveri Inalabili	85	7	9	127	24	15	17		39	323
Polveri Respirabili	34	7		107		7	68	1	22	246
Polveri di Farina										0
Polveri inalabili										0
Silice Libera Cristallina				54			63	9		126
Solfuro di Carbonio	16								6	22
Sostanze Organiche Alogenate	291	1		40						332
Sostanze Organiche Volatili	2.189	923		665	361	25	72		45	4.280
Totale	5.633	962	9	5.305	725	292	231	10	229	13.396

ai dati storici consente di documentare e misurare i cambiamenti dell'intensità e delle caratteristiche delle esposizioni a sostanze chimiche. Il confronto dei valori delle misure tra i vari comparti produttivi può fornire utili indicazioni per pianificare le attività di monitoraggio, controllo e bonifica. Nello specifico, ESP ALP può essere utile a:

- migliorare la mappatura del rischio chimico sul territorio piemontese;
- restituire ai Servizi di Prevenzione negli Ambienti di Lavoro informazioni utili per meglio orientare le proprie attività;
- proporre specifici programmi di vigilanza per i comparti a maggior rischio di esposizione.

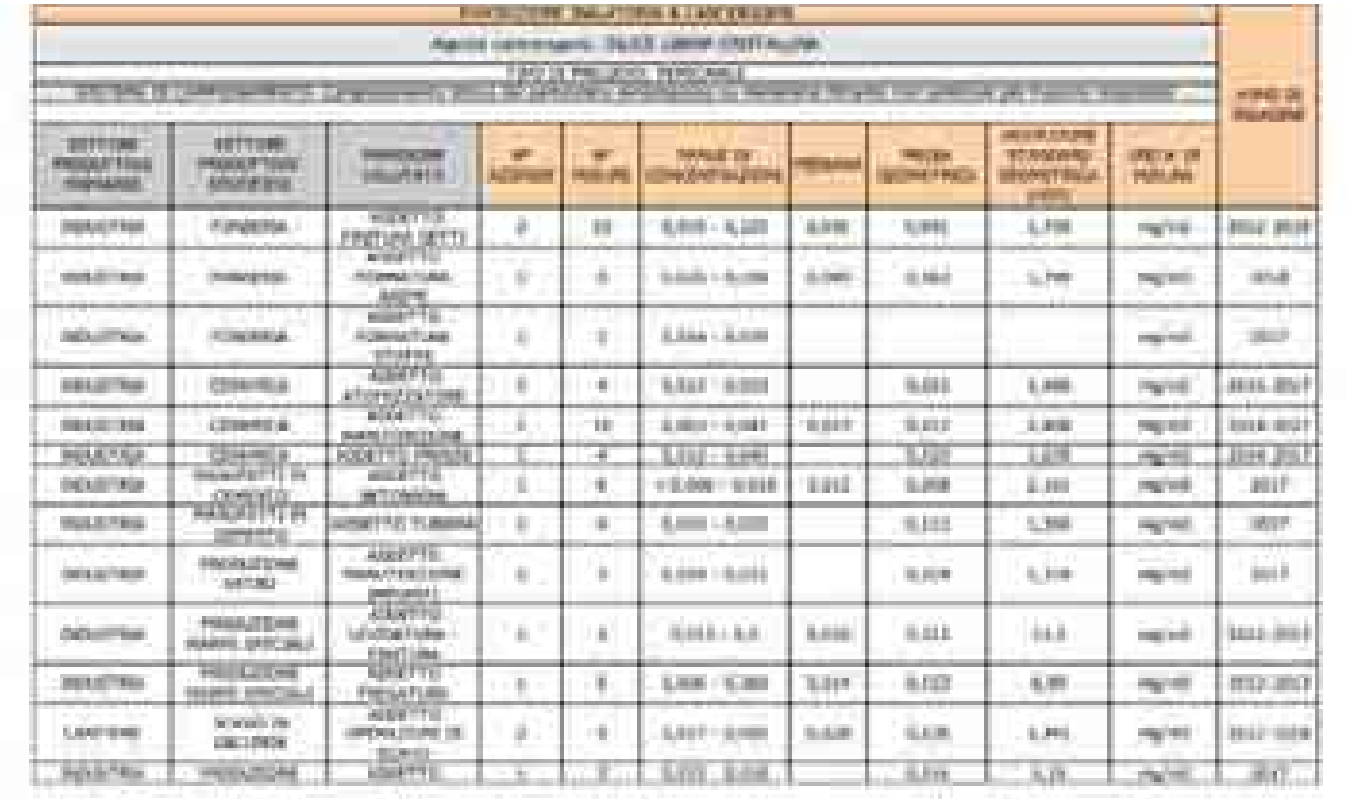
Nel medio termine si prevede che il personale di ARPA Piemonte prosegua con l'inserimento dei dati di esposizione professionale relativi a misure provenienti dagli interventi sia attualmente in corso sia effettuati negli anni passati.

La disponibilità delle misure raccolte permette di caratterizzare le esposizioni, per gli agenti di interesse, in base al periodo temporale e al comparto di attività economica; il gruppo di lavoro che ha curato la progettazione e

Tabella IV. ***Numero di misure per alcuni agenti selezionati e anno di rilevazione***

Denominazione agente	CAS	Anno							Totale
		2005-2009	2010-2014	2015	2016	2017	2018	2019-2020	
Benzene	71-43-2	163	180	21	22	51	25	30	492
Formaldeide	50-00-0	241	137	38	27	63	38	18	562
Manganese (Mn)	7439-96-5	94	43	7	0	97	15	0	256
Silice libera cristallina - cristobalite - quarzo alfa	14464-46-1 1317-95-9 14808-60-7	22	57	0	0	60	19	19	177
Totale		520	417	66	49	271	97	67	1.487

Tabella V. ***Utilizzo delle informazioni raccolte relative alla Silice libera cristallina (estratto per Data Base Gruppo Nazionale Cancerogeni)***



l'alimentazione di ESP ALP ha intenzione di effettuare alcuni di questi approfondimenti con particolare attenzione agli agenti per i quali sono stati recentemente definiti dal Parlamento Europeo nuovi limiti di esposizione professionale, come ad esempio per il Benzene e il Nichel (4).

La possibile pubblicazione di ESP ALP in ambiente web potrà rendere disponibili i dati ad altri professionisti. È altresì possibile prevedere che altre strutture del sistema pubblico di vigilanza regionale ed eventualmente del sistema delle aziende che effettuano monitoraggio di agenti chimici riversino in questo ambiente le misure da loro effettuate. Ciò consentirebbe un arricchimento delle informazioni in riferimento anche ad altri territori.

Infine, è auspicabile, nonché tecnicamente praticabile, rendere stabile ed espandere l'integrazione di ESP ALP con altre fonti utili ad aumentarne le potenzialità informative. Oltre all'integrazione con le fonti del Censimento Istat 2011 delle attività economiche e con gli elenchi delle ditte assicurate all'INAIL, si potrebbe attivare il collegamento con banche dati chimiche e tossicologiche fra cui, in particolare, MATline - Matrice di predizione delle esposizioni a sostanze cancerogene (5), consentendo di ottenere per gli agenti cancerogeni informazioni su caratteristiche chimiche, valori limite di esposizione occupazionale, classificazione CLP e organi bersaglio.

L'integrazione con altre fonti relative alle caratteristiche delle ditte, quali i dati sempre aggiornati del Registro Imprese della Camera di Commercio, consentirebbe di ottenere ulteriori informazioni su ditte, attività economiche e numero di addetti.

Tabella VI. ***Utilizzo delle informazioni raccolte relative alla Formaldeide (estratto per Data Base Gruppo Nazionale Cancerogeni)***

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MEDICINA DEL LAVORO

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IMPAcT-RLS2: Indagine nazionale sulla salute e la sicurezza sul lavoro: il ruolo dei Rappresentanti dei Lavoratori per la Sicurezza

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RIASSUNTO. L'Indagine IMPAcT-RLS2 si inserisce nel più ampio programma di ricerca INSuLa2, la cui prima edizione, condotta nel 2014 e rivolta a tutti gli attori della prevenzione, ha approfondito aspetti della tutela della salute e sicurezza sul lavoro (SSL) secondo il punto di vista delle varie figure intervistate. La *survey* indirizzata ai Rappresentanti dei lavoratori per la sicurezza (RLS), focalizzata inizialmente su tre contesti regionali, è stata implementata grazie all'indagine IMPAcT-RLS, realizzata nel 2016, che ha coinvolto un campione di circa 2.100 soggetti, rappresentativo a livello nazionale, per dimensione aziendale e settore di attività economica. L'indagine ha evidenziato l'importanza di disporre di informazioni sempre più approfondite sul ruolo dei RLS e di monitorarne l'andamento nel tempo. Il presente studio ribadisce l'importanza di istituire rilevazioni periodiche e replicabili, finalizzate ad aumentare le conoscenze e la consapevolezza sui sistemi di prevenzione e promuovere interventi sempre più mirati per il miglioramento della tutela della SSL.

Parole chiave: Rappresentante dei lavoratori per la sicurezza, indagine, percezione del rischio.

ABSTRACT. IMPAcT-RLS2: A national Survey on Occupational Safety and Health: the role of the Health and Safety Representatives. The IMPAcT-RLS2 survey is part of a larger context of INSuLa2 research program; its first edition was conducted in 2014 and targeted to all prevention professionals, investigating occupational health and safety (OSH) protection issues perceived by the various professionals' point of view. The survey addressed to Health and Safety Representatives (HS reps.), focused on three regional contexts, was further implemented in 2016 through the IMPAcT-RLS survey, which involved a sample representative at national level, by company size and economic activity sector consisting of about 2,100 subjects. The survey highlighted the importance of having ever more in-depth information on the role of HS reps. and monitoring their evolution over time. This study arises from the need to create periodic and replicable surveys, aimed at increasing knowledge and awareness of prevention systems and promoting increasingly targeted interventions for improving the protection of OSH.

Key words: *Health and safety representative, survey, risk perception.*

Introduzione

Il Rappresentante dei lavoratori per la sicurezza (RLS) è un attore fondamentale del sistema di prevenzione. La letteratura e le ricerche condotte fino ad oggi hanno sottolineato il rapporto fondamentale esistente tra le condizioni in cui i RLS operano, il loro coinvolgimento attivo, i modelli di prevenzione, la cultura della salute e sicurezza aziendale e le prestazioni di salute e sicurezza raggiunte dall'organizzazione.

Molti studi a livello internazionale hanno analizzato il ruolo dei RLS nei processi di gestione del rischio in materia di salute e sicurezza sul lavoro (SSL) in azienda (1-4). In generale, dall'analisi della letteratura si evince come, generalmente, l'efficacia del ruolo abbia un effetto positivo sulla SSL (5) e che la presenza e la consultazione del RLS abbia migliorato le performances in termini di SSL, con un effetto, ad esempio, sui tassi di infortunio (6-8). Allo stesso tempo, però, si rilevano alcune criticità strettamente legate alla necessità di stabilire fino a che punto le strategie di partecipazione esistenti siano state efficaci (8,9). Questi punti di forza e di debolezza sono fortemente influenzati da alcuni fattori legati alle caratteristiche delle aziende in cui il RLS svolge la propria attività, come il settore economico di appartenenza, la dimensione e la posizione geografica; questi fattori devono essere necessariamente considerati per comprendere il ruolo effettivo dei RLS nel sistema di prevenzione della SSL (10-12).

La prima edizione dell'Indagine nazionale sulla salute e sicurezza sul lavoro (INSuLa), condotta nel 2014 (13) e rivolta ai lavoratori, datori di lavoro (DL), responsabili del servizio prevenzione e protezione (RSPP), RLS, medici competenti (MC) e servizi per la prevenzione e sicurezza negli ambienti di lavoro (SPSAL), ha permesso di studiare in modo più approfondito la percezione sulla SSL dal punto di vista dei diversi attori della prevenzione, nonché analizzare le relazioni sul territorio nazionale. Al fine di implementare il campione di RLS, focalizzato inizialmente sui tre contesti regionali maggiormente attivi in Italia (Emilia Romagna, Toscana e Marche) (14), è stata realizzata nel 2016 l'Indagine sui modelli partecipativi aziendali e territoriali per la salute e la sicurezza del posto di lavoro: il ruolo dei RLS e le interazioni con gli attori della prevenzione (IMPAcT-RLS) (15). Lo studio, realiz-

zato nell'ambito di un partenariato costituito da Università, Istituti di ricerca e principali rappresentanze sindacali nazionali, ha analizzato un campione di circa 2.100 soggetti, rappresentativo a livello nazionale, per dimensione aziendale e settore di attività economica. L'indagine ha mostrato l'importanza di avere a disposizione informazioni sempre più approfondite sul ruolo dei RLS e di monitorarne l'andamento nel tempo, anche tramite la conduzione di rilevazioni periodiche e replicabili, che possano aumentare le conoscenze e la consapevolezza sul funzionamento dei sistemi di prevenzione, contribuendo alla definizione di interventi sempre più mirati per il miglioramento della tutela della SSL.

In tale ambito il presente progetto, maturato da un'esperienza di rete consolidata composta da Politecnico di Milano, Fondazione Di Vittorio, Università degli Studi di Perugia e con il coinvolgimento diretto di Cgil, Cisl, Uil nazionali, è stato inserito nel più ampio programma di ricerca INSuLa, coordinato dall'INAIL. A partire dagli studi precedenti realizzati a livello nazionale e internazionale, il progetto è finalizzato alla definizione e alla messa a punto di metodologie e strumenti per la realizzazione di un'indagine campionaria periodica rivolta ai RLS - aziendali, territoriali e di sito produttivo - sui temi della SSL e sulla loro partecipazione nei sistemi di prevenzione. Tale metodologia, oltre ad essere replicabile e basata su caratteristiche di estensione e rappresentatività, risulta anche solida, sufficientemente flessibile e in grado di adattarsi ai mutamenti nel contesto normativo, organizzativo e tecnologico.

Metodologia

La metodologia di campionamento proposta è finalizzata a garantire la massima rappresentatività statistica del campione per macroregione geografica (nord-est, nord-ovest, centro, sud e isole) e settore di attività economica (classificazione Ateco 2007).

L'indagine è stata progettata tramite una stima indiretta del numero di RLS che operano sul territorio italiano, partendo dal censimento nazionale delle aziende disaggregate per settore merceologico e dimensione (fonte ISTAT) e applicando ad esse i requisiti richiesti dalla normativa circa il numero minimo di RLS presenti in azienda (D.Lgs. 81/2008 e s.m.i.).

La popolazione di RLS è stata individuata grazie al coinvolgimento diretto delle principali sigle sindacali (Cgil, Cisl e Uil) nazionali, partendo dalle liste afferenti a ciascuna sigla sindacale di dimensione doppia rispetto al campione teorico desiderato, per ogni strato della popolazione. Il campione teorico è stato estratto in modo casuale; in fase di somministrazione, al fine di raggiungere la popolazione target, sono seguite azioni di aggiustamento, rilasciando il vincolo di estrazione casuale e la proporzione degli strati.

Il questionario è stato somministrato via *web* tramite la piattaforma *Survey Monkey*.

La rilevazione estensiva, condotta - previa fase di test pilota - nel periodo febbraio 2019-gennaio 2020, ha riguardato un campione di 1049 RLS aziendali.

Questionario di rilevazione

Il questionario di indagine è stato sviluppato a partire dal precedente utilizzato in IMPAcT-RLS (15), tramite un processo di miglioramento ed affinamento volto a massimizzarne l'efficacia, in termini di comprensibilità, facilità di compilazione e bilanciamento tra completezza e onerosità di compilazione. Il percorso partecipativo che ha portato alla definizione del questionario è avvenuto attraverso il coinvolgimento delle organizzazioni sindacali e dei RLS, tramite *focus group* e interviste. Anche in questa edizione è stato privilegiato l'utilizzo, laddove esistenti, di scale di misura già testate e validate in altre ricerche sia nazionali che internazionali. Sono state, inoltre, mantenute alcune domande utilizzate nelle ricerche precedenti per garantire la confrontabilità e l'andamento nel tempo; sono state, inoltre, introdotte nuove tematiche per contemplare le novità e peculiarità del periodo di riferimento.

Relativamente alla tipologia di scale utilizzate, sono state considerate scale ordinali e scale *Likert*/*Likert-like*, cercando un bilanciamento tra precisione del dato e onerosità di compilazione. Il questionario è stato testato su un campione di 30 RLS.

La versione finale del questionario indirizzato ai RLS aziendali si compone di 71 domande e 210 Item.

La Tabella I riporta in maniera sintetica i principali contenuti di ciascuna sezione.

Risultati

L'analisi statistica dei risultati è stata svolta tramite il *software* SPSS v. 25.

In questa sezione vengono descritti i risultati preliminari dell'indagine in riferimento ad alcune sezioni del questionario, focalizzando in particolare l'attenzione sulle caratteristiche del campione intervistato, sulla percezione del rischio in azienda, sulle criticità riscontrate nello svolgimento dell'attività di RLS e sulla percezione del proprio ruolo.

Si riportano, inoltre, approfondimenti relativi ad alcuni confronti basati sulle principali caratteristiche aziendali contemplate nell'indagine, che sono risultati statisticamente significativi (sono stati considerati significativi valori di $p<0,05$).

Caratteristiche del campione dei RLS

Il campione, composto da 1049 soggetti, è costituito prevalentemente da RLS di genere maschile (85,5%), di età compresa tra 45-54 (46,0%); la distribuzione per area geografica risulta piuttosto equilibrata anche se con una prevalenza di RLS che operano nel nord ovest (32,8%). Il ruolo ricoperto in azienda è generalmente di operaio o impiegato, con pressoché la stessa percentuale (solo il 7,4% ha la qualifica di funzionario o dirigente), e il titolo di studio più frequente è di scuola media superiore (62,9%).

Il settore principale da cui provengono gli intervistati è quello dell'industria (39,5%), in particolare le attività ma-

Tabella I. ***Sezioni del questionario e principali contenuti***

Sezione	Contenuti principali
A. Caratteristiche socio-demografiche e lavorative del RLS	Età, genere, nazionalità, titolo di studio, qualifica contrattuale, anzianità nel ruolo
B. Contesto lavorativo	Regione di afferenza dell'unità produttiva e caratteristiche, settore economico, dimensione aziendale, modalità di lavoro praticate
C. Rischi sul lavoro, infortuni e malattie professionali	Giudizio sugli aspetti che contribuiscono a determinare un infortunio; andamento dei principali indicatori su infortuni e malattie professionali; esposizione a rischi in azienda e fattori di rischio personali
D. Cultura e Sistemi di Gestione della Salute e Sicurezza in azienda	Formalizzazione di un Sistema di Gestione per la Salute e Sicurezza (SGSS) in azienda; utilizzo di indicatori di prestazione di salute e sicurezza; promozione di azioni di miglioramento delle condizioni di SSL; politica adottata in ambito prevenzionale; procedure operative in materia di SSL; eventuali premi/incentivi riconosciuti
E. Rapporto con i lavoratori e le altre figure della prevenzione	Modalità di comunicazione con i lavoratori e giudizio sul rapporto con le varie figure in azienda. Presenza di conflitti con i dirigenti/preposti in merito a vari aspetti
F. Informazione, consultazione e coinvolgimento del RLS	Possibilità di accesso e frequenza ai documenti (DVR, giudizi di idoneità alla mansione, documenti delle visite ispettive, ecc…). Giudizio sulla completezza del DUVRI; frequenza della riunione periodica e informazioni ricevute su incidenti e infortuni e/o su questioni legate alla SSL e sul ruolo di RLS. Consultazione come RLS in merito a vari aspetti
G. Formazione su SSL	Giudizio generale sul valore della formazione obbligatoria dei lavoratori e sull'efficacia delle diverse modalità formative. Dettagli sull'eventuale formazione aggiuntiva. Argomenti su cui hanno ricevuto la formazione e su cui vorrebbero riceverla
H. Ruolo del RLS	Motivazioni e soddisfazione nello svolgimento del ruolo di RLS; percezione sul giudizio dei lavoratori rispetto al proprio ruolo; ambiti di miglioramento nello svolgimento della propria attività
I. Relazioni industriali e dialogo sociale	Modalità di elezione/designazione. Giudizio sugli accordi aziendali e sul rapporto tra parte sindacale e datoriale. Frequenza delle assemblee con i lavoratori su tematiche di SSL. Presenza in azienda di comitati paritetici, gruppi di lavori congiunti, procedure formalizzate aziendali per il confronto tra RLS e responsabili datoriali su SSL

nifatturiere (26,9%); seguono gli Altri servizi (17,7%), la Sanità (9,1%) e la Pubblica Amministrazione (8,9%). La maggior parte dei RLS proviene dal settore privato nazionale (35,5%) e multinazionale (34,3%), il 17,9% da enti pubblici e il rimanente 12,3% da imprese controllate dalla pubblica amministrazione.

La maggior parte dei RLS intervistati (64,9%) opera in aziende di grandi dimensioni con oltre 250 addetti. Circa l'80% del campione svolge anche il ruolo di RSA/RSU.

Tra le tipologie di lavoro presenti in azienda, il lavoro in turni è presente nel 71,1% dei casi, seguito dalla "reperibilità" e dal lavoro notturno (54% circa per entrambe le tipologie) e la mobilità dei lavoratori sul territorio nazionale e internazionale (37,4%). Solo nel 15,4% dei casi viene svolto il lavoro stagionale e nel 16,7% il lavoro vincolato.

Nelle Tabelle IIa e IIb sono riportate le principali caratteristiche socio-demografiche e aziendali del campione di indagine.

Rischi sul lavoro, infortuni e malattie professionali

Relativamente all'andamento negli ultimi 3 anni degli indicatori di rischio rispetto al contesto in cui l'intervistato opera come RLS, il 42,9% dichiara che l'indice di frequenza degli infortuni risulta stabile e il 32,5% in diminuzione; stessa tendenza si evidenzia rispetto all'indice di gravità degli stessi. Una percentuale consistente del campione (37,4%) dichiara di non essere a conoscenza del numero di malattie professionali denunciate in azienda (Figura 1).

Se i risultati vengono disaggregati per dimensione aziendale, emergono associazioni significative sia rispetto all'indice di frequenza che di gravità degli infortuni. In particolare, la percentuale di chi dichiara che l'indice di frequenza sia aumentato cresce in maniera significativa con la dimensione aziendale (dall'8,3% registrato nelle micro azienda al 15,4% delle grandi); percentuali maggiori di chi non sa rispondere alla domanda si evidenziano nelle aziende con meno di 10 addetti.

L'andamento del numero di malattie professionali denunciate risulta, invece, associato con la macro area geografica, con percentuali di chi sostiene che siano in diminuzione registrate tra i RLS del sud e isole (23,5%) significativamente superiori rispetto a chi opera nel nord (16,8%) e centro Italia (16,9%).

Differenze significative si registrano anche rispetto al settore economico di appartenenza; i settori che presentano la percentuale più elevate di RLS che sostengono che l'indice di frequenza di infortunio sia aumentato si evidenziano nell'Industria (18,9%) e nelle Costruzioni (15,6%). Circa la metà di RLS afferenti al settore agricolo ritiene che l'indice di gravità degli infortuni sia diminuito negli

Tabella IIa. ***Caratteristiche socio-demografiche***

Variabile	**v.a.**	**%**
Genere		
Maschi	876	85,5
Femmine	149	14,5
Classe di età		
25-34	39	3,8
35-44	184	17,7
45-54	477	46,0
55-64	330	31,8
65 e oltre	8	0,8
Età media (Dev. Stand.)	*50,32 (7,79)*	
Titolo di studio		
Licenza elementare	4	0,4
Licenza media inferiore	217	20,9
Diploma scuola media superiore	654	62,9
Laurea (I-II livello e vecchio ordinamento)	118	11,4
Specializzazione post-laurea	46	4,4
Area geografica		
Nord Ovest	344	32,8
Nord Est	287	27,4
Centro	200	19,1
Sud e Isole	218	20,8
Qualifica contrattuale		
Dirigente/Direttore/Funzionario/Quadro	77	7,4
Impiegato	463	44,5
Operaio	464	44,6
Altro	36	3,5

Tabella IIb. ***Caratteristiche aziendali***

Variabile	**v.a.**	**%**
Dimensione aziendale		
1-9 addetti*	13	1,3
10-49 addetti	77	7,7
50-249 addetti	231	23,2
250 e oltre addetti	643	64,5
Attività economica - Ateco 2007		
Agricoltura - Agricoltura, silvicoltura e pesca	12	1,1
Industria - Attività manifatturiere ed estrattive, altre attività	414	39,5
Costruzioni	70	6,7
Commercio - Commercio all'ingrosso e al dettaglio, attività di alloggio e ristorazione)	51	4,9
Trasporti - Trasporto e magazzinaggio	46	4,4
Attività finanziarie - Servizi di Informazione e comunicazione, Attività finanziarie e assicurative e immobiliari	45	4,3
Attività professionali - Attività professionali, scientifiche e tecniche, amministrative e di servizi di supporto	37	3,5
Pubblica Amministrazione - Amministrazione pubblica e difesa, istruzione	93	8,9
Sanità - Sanità e assistenza sociale	95	9,1
Altri servizi - Attività artistiche, sportive, di intrattenimento e divertimento, famiglie/convivenze, organizzazione/organismi extraterritoriali	186	17,7
L'unità produttiva in cui opera come RLS appartiene a:		
Azienda multinazionale controllata da Enti/Amm. pubbliche	48	4,7
Azienda nazionale controllata da Enti/Amm. pubbliche	79	7,7
Azienda/Ente privato multinazionale	353	34,3
Azienda/Ente privato nazionale	365	35,5
Ente/Amministrazione pubblica	184	17,9
Ruolo coincidente con RSA/RSU		
Sì	840	80,5
No	203	19,5
Modalità di lavoro praticate in azienda (sì/no/non so)	Risposta (sì)	% (sì)
Lavoro in turni	725	71,1
Lavoro notturno	519	54,1
Lavoro stagionale	136	15,4
Lavoro vincolato (catena di montaggio)	148	16,7
Job Rotation	288	32,4
Reperibilità	512	54,4
Mobilità dei lavoratori sul territorio nazionale/internazionale	337	37,4
Smart working/telelavoro	273	30,2

* In questa tipologia di aziende è prevista, di solito, la figura del RLS territoriale a cui è stata dedicata una rilevazione costruita *ad hoc*.

ultimi 3 anni; tale valore risulta significativamente più elevato rispetto alla percentuale media che si attesta intorno al 30%.

Fra i rischi per la salute e sicurezza presenti in azienda, il rischio stress lavoro-correlato (SLC) risulta essere, in base al giudizio dei RLS intervistati, il principale rischio a cui i lavoratori dell'azienda risultano esposti, avendo ottenuto su una scala variabile da 1=non esposti a 5=molto esposti, un valore medio pari a 3,79. Seguono il rischio biomeccanico (3,45) e rischio fisico (3,21); i punteggi medi registrati per le rimanenti tipologie di rischio si attestano al di sotto di 3; il rischio da eventi naturali viene percepito dagli intervistati come quello a cui i lavoratori si sentono meno esposti (media=1,68) (Figura 2).

Anche in quest'area tematica l'analisi dei dati per gruppi distinti a seconda delle variabili aziendali ha fatto emergere differenze significative; in base al giudizio dei RLS, l'esposizione al rischio stress lavoro-correlato e ad altri rischi psicosociali tende, così come il rischio da videoterminale, ad aumentare significativamente con la dimensione aziendale: si evidenzia, in particolare per il rischio SLC, che nelle micro-aziende fa registrare un valore medio di 3,31, significativamente inferiore rispetto a quello delle piccole (3,44), medie (3,57) e grandi aziende (3,95). Relativamente al rischio da lavoro a videoterminale (VDT), si passa dall'1,92 registrato nelle micro-aziende a 3,02 delle aziende di grandi dimensioni. Viceversa, l'esposizione a rischi fisici o legati a frequenti spostamenti e trasferte per lavoro risulta maggiormente percepita nelle micro imprese.

Ad eccezione del rischio da eventi naturali, per tutte le altre tipologie, la percezione dei RLS sul grado di esposizione dei lavoratori si differenzia anche in funzione dei settori produttivi in cui operano gli intervistati. Il settore che presenta il punteggio medio più elevato riguardo al rischio stress lavoro-correlato è quello dei servizi informazione/comunicazione (4,47) e Sanità (4,32), mentre quello con il punteggio medio più basso si registra in Agricoltura (3,25); per il rischio biomeccanico risulta essere il settore sanitario (3,99) e trasporto e magazzinaggio (3,70); il settore sanitario risulta essere anche quello in cui si registrano i punteggi medi più elevati in relazione all'esposizione al rischio biologico (4,04) e quello da altri rischi psicosociali (3,59). Il settore delle costruzioni risulta essere quello per il quale si evidenziano, in base al giudizio degli intervistati, i punteggi medi più elevati del grado di esposizione al rischio fisico (3,76) e chimico (3,28). I livelli di esposizione al rischio da lavoro al VDT significativamente più elevati si registrano nei servizi di informazione (4,25) e nella Pubblica amministrazione (3,61).

Relativamente ai fattori di rischio personali, la valutazione del rischio svolta in azienda tiene esplicitamente in considerazione soprattutto la disabilità e inabilità (66,2%) e le donne in gravidanza (62,7); la provenienza da altri paesi viene considerata solo nel 22,3% dei casi (Figura 3). Dall'incrocio per dimensione aziendale si evidenzia una maggiore tendenza nelle grandi aziende a prendere in considerazione la tematica della disabilità (66,9%) rispetto al 33,3% registrato nelle micro; tale tendenza si evidenzia anche nelle aziende del Nord (68,2%) e Centro (67,3%) rispetto a Sud e Isole (59,5%). La stessa situazione si verifica anche per la provenienza da altri paesi e il fattore gravidanza. La valutazione del rischio tiene in considerazione l'età prevalentemente nei settori Agricoltura (91,7%) e

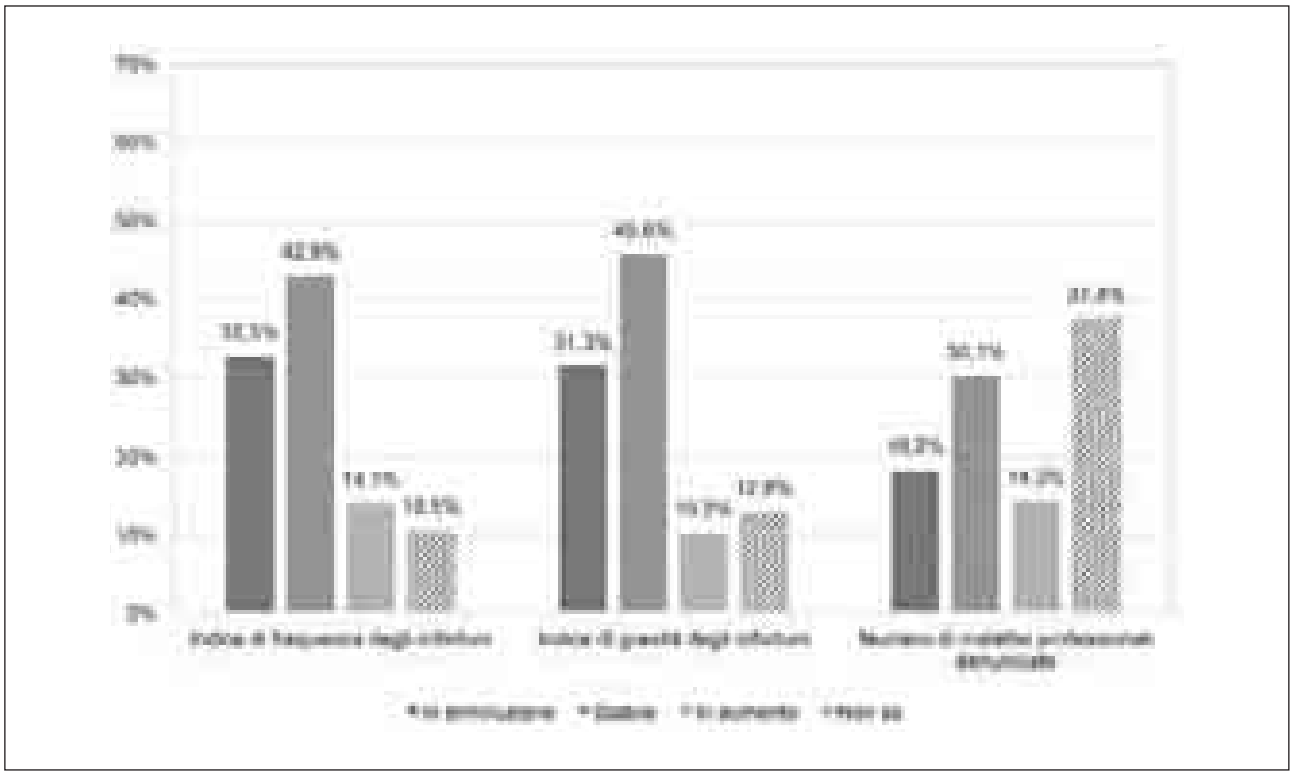

Figura 1. ***Andamento negli ultimi 3 anni degli indici su infortuni/malattie professionali relativi al contesto in cui opera il RLS. Valori percentuali***

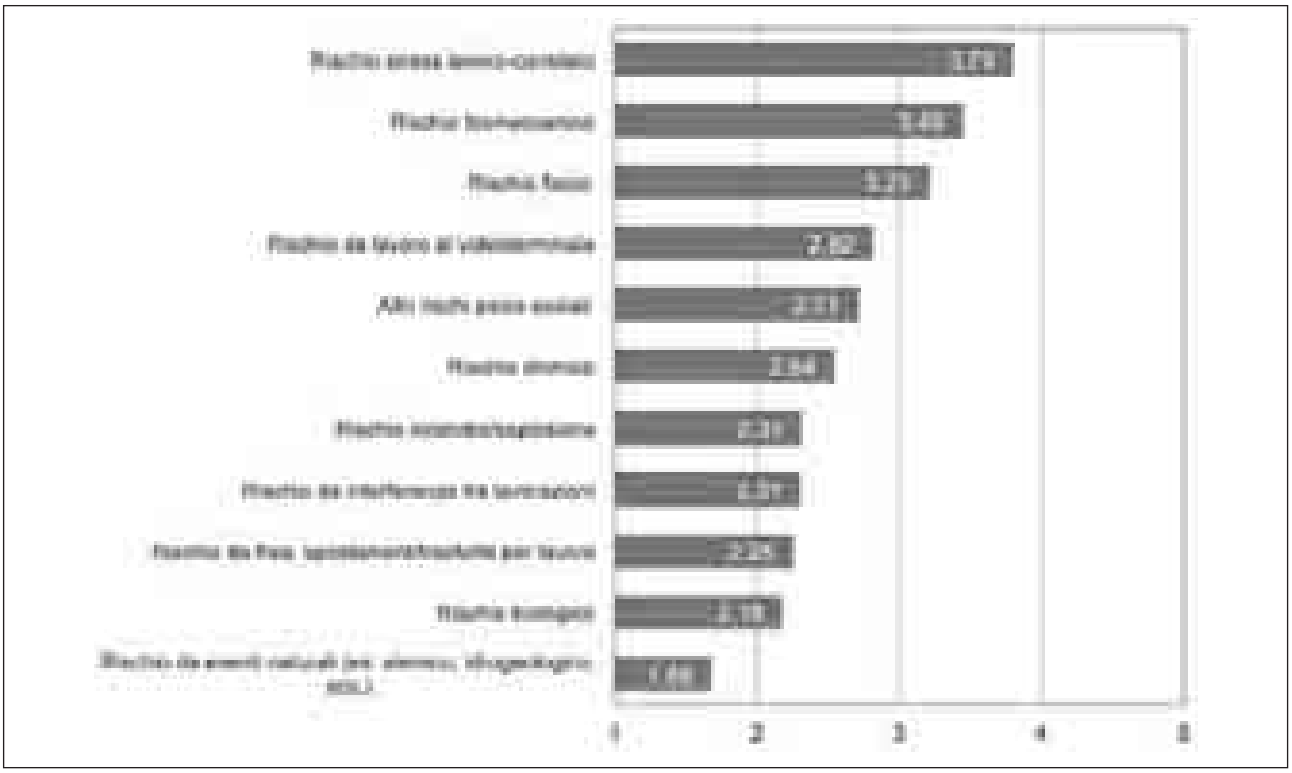

Figura 2. ***Percezione del RLS sul grado di esposizione dei lavoratori della propria azienda ai vari rischi. Valori medi (*)***

(*) punteggio variabile da 1=non esposti a 5=molto esposti

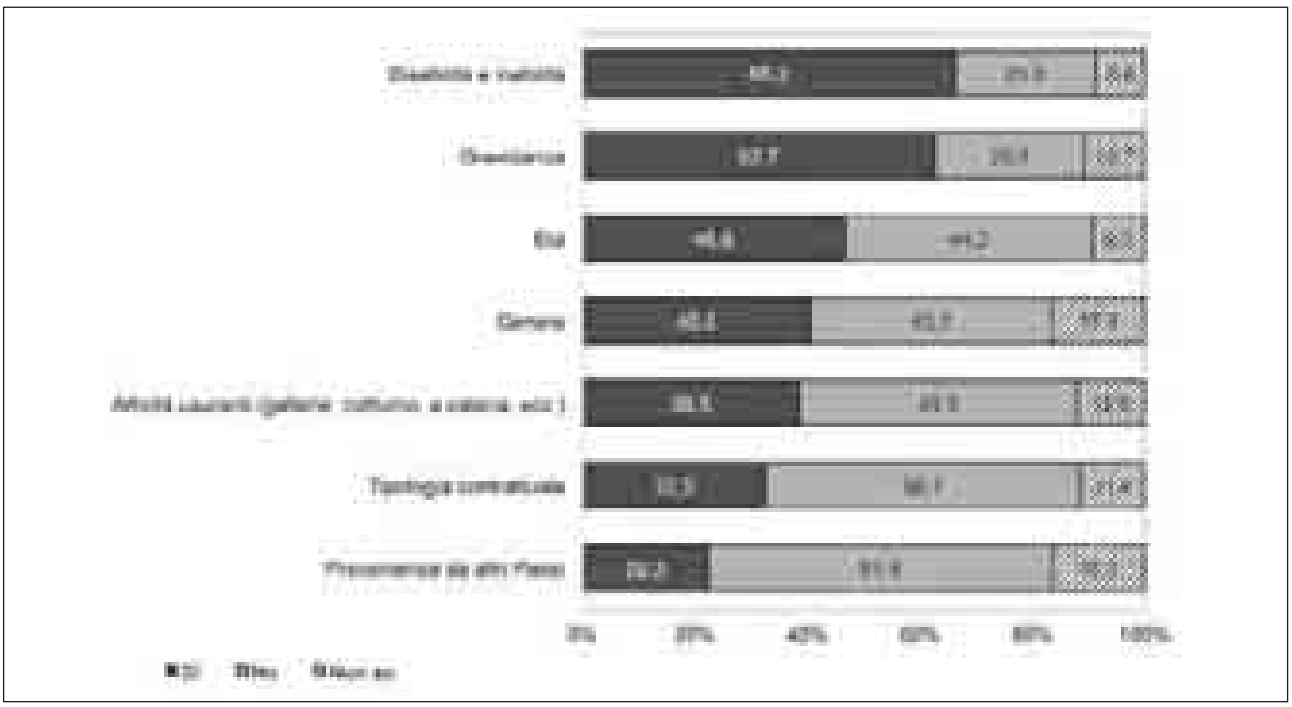

Figura 3. ***"Nell'unità produttiva in cui opera, la valutazione del rischio tiene esplicitamente in considerazione i seguenti fattori di rischio personali?". Valori Percentuali***

Trasporti (69,7%), lo stato di gravidanza in Sanità (78,0%), settore in cui si registra anche una percentuale elevata (72,0%) di aziende in cui la valutazione del rischio tiene in considerazione la disabilità come fattore di rischio personale, insieme al settore dei Trasporti/magazzinaggio (80,0%). La tematica connessa alla provenienza da altri paesi fa emergere la percentuale più alta nei Trasporti (48,9%) e più bassa nei servizi di Informazione/comunicazione (8,9%). Da evidenziare che relativamente alle attività usuranti (lavoro in gallerie, notturno, a catena, ecc.), maggiormente contemplata come fattore di rischio personale nei Trasporti (58,7%), in Agricoltura (50,0%) e nelle Costruzioni (43,5%), oltre il 20% di RLS impiegati in Attività professionali non sa rispondere alla domanda.

Rapporti con le altre figure della prevenzione

I rapporti più collaborativi instaurati dai RLS all'interno dell'unità produttiva si sviluppano soprattutto con la rappresentanza sindacale, con i lavoratori, con il RSPP e con il medico competente; i rapporti con i dirigenti, i datori di lavoro e i preposti risultano più conflittuali che collaborativi (Tabella III).

Anche in quest'area di indagine si evidenziano differenze significative soprattutto rispetto alla dimensione dell'azienda in cui il RLS opera. I RLS del Sud e Isole dichiarano di avere rapporti con il MC e i dirigenti più collaborativi (51,5% e 33,8%, rispettivamente) rispetto a coloro che operano nel Nord (41,9% e 24,1%). Ancora rapporti più collaborativi con i lavoratori si registrano tra i RLS del Sud e Isole e del Centro.

Relativamente ai settori produttivi di appartenenza, relazioni più conflittuali che collaborative con i dirigenti si evidenziano nelle attività finanziarie (34,9%); percentuali significativamente più basse di chi giudica collaborativi i rapporti con gli altri RLS della stessa azienda si registrano nel settore delle costruzioni (32,8%) e con il RSPP nell'industria (40,6%). Percentuali significativamente più basse della media di chi giudica "collaborativo" il rapporto con il MC si registrano nel settore delle attività finanziarie (31,8%).

Il ruolo di RSPP viene svolto nel 73,6% dei casi da una figura interna all'azienda diversa dal DL e per il 20,4% da una figura esterna.

Nell'unità produttiva dei RLS intervistati, i conflitti con i dirigenti e/o preposti si verificano, principalmente, su questioni legate ai cambiamenti organizzativi (57,7%) e agli investimenti nel miglioramento di attrezzature e tecnologie (53,0%) (Figura 4). I risultati incrociati con la dimensione aziendale fanno emergere differenze significative; in particolare, entrambe le questioni sopra citate risultano maggiormente percepite come motivazioni di conflitto nelle grandi aziende (56,1%) rispetto alle imprese con 10-49 addetti (41,1%). Rispetto ai settori economici, l'offerta di formazione per i RLS/lavoratori viene considerata una motivazione importante nel conflitto con i dirigenti, in particolare dai RLS afferenti alla Sanità (46,1%); le percentuali più basse si registrano in agricolture e attività professionali (25,0%, in entrambi i casi). I cambiamenti organizzativi risultano, invece, un importante fat-

Tabella III. ***Rapporti con le atre figure in azienda. Valori percentuali***

Figura	Figura non presente	Non ho rapporti	Conflittuale	Più conflittuale che collaborativo	Più collaborativo che conflittuale	Collaborativo
DL / DELEGATO	2,8%	8,9%	5,3%	22,6%	29,9%	30,4%
DIRIGENTI	5,1%	8,0%	6,1%	22,6%	30,9%	27,3%
PREPOSTI	2,2%	3,9%	6,2%	17,9%	32,0%	37,7%
ALTRI RLS STESSA AZIENDA	24,4%	3,2%	1,4%	4,2%	14,5%	52,3%
RSPP / ASPP	3,1%	4,2%	3,2%	12,1%	31,6%	45,9%
MC AZIENDALE	1,8%	13,6%	1,5%	8,9%	25,7%	48,5%
LAVORATORI	0,1%	0,3%	0,7%	6,1%	32,9%	59,9%
RSU / RSA	4,0%	1,8%	1,0%	4,3%	17,8%	71,0%

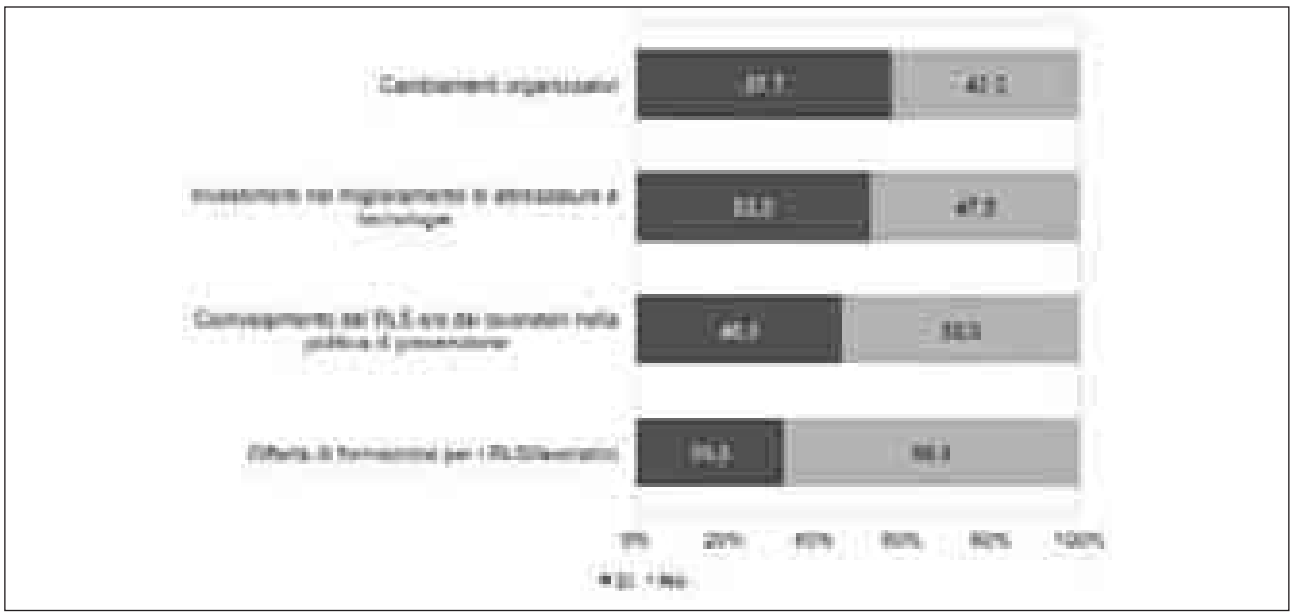

Figura 4. ***Aspetti su cui si verificano conflitti in azienda con dirigenti/preposti. Valori Percentuali***

tore di conflitto per il 75,0% dei RLS afferenti al settore informazione e comunicazione e attività finanziarie, rispetto ad esempio al 43,9% registrato nel settore delle costruzioni.

Formazione su salute e sicurezza sul lavoro

Il 95,5% dei RLS intervistati afferma di aver ricevuto la formazione di base prevista dalla normativa e il 79,7% di aver svolto gli aggiornamenti previsti; si evidenzia che il 12,1% del campione dichiara di non aver ricevuto gli aggiornamenti previsti nonostante sia stato eletto da più di un anno. Il 47,7%, inoltre, non ha ricevuto nell'ultimo anno ulteriori ore di formazione aggiuntive su SSL, oltre a quella obbligatoria. La formazione è stata fornita nel 54,2% dei casi dall'azienda, dal 44,5% dai sindacati e dal 27,8% dagli organismi paritetici. Tra le varie modalità formative, su una scala variabile da 1 = per nulla efficace a 5 = del tutto efficace, escludendo tutti coloro che non hanno avuto esperienza nella fruizione di alcuna modalità formativa proposta, alla formazione in aula con esercitazioni tecnico-pratiche e alle simulazioni sul luogo di lavoro viene assegnato il punteggio medio più elevato (3,99, per entrambe le modalità); seguono le lezioni in aula con lavori di gruppo (3,87), con lezioni frontali (3,83), affiancamento (3,81) e quindi e-learning/formazione al computer (2,65).

I principali argomenti trattati nella formazione sono: il ruolo dei soggetti nella prevenzione (87,0% dei casi), il rischio derivante dall'uso scorretto dei dispositivi di protezione individuale (DPI) (71,8%), il rischio chimico, biologico o rischio derivante dall'esposizione ad agenti fisici (66,6%), prevenzione degli infortuni (64,2%), prevenzione e gestione delle emergenze (61,5%) e uso/manutenzione delle attrezzature (60,9%). Gli argomenti trattati invece in modo più limitato riguardano: bullismo o mobbing (35,0%) e i sistemi di certificazione SGSL (29,0%). Proprio su quest'ultima categoria di argomenti il campione intervistato dichiara di avere bisogno di maggiori approfondimenti (56,2%), seguono le tecniche di comunicazione (55,7%), violenza, bullismo e mobbing (54,1%), ma anche la guida alla lettura dei documenti ufficiali (51,4%) e l'organizzazione del lavoro (50,1%) (Figura 5).

Ruolo dei RLS

Le ragioni che hanno portato i RLS a ricoprire questo ruolo sono da ricondurre principalmente alla sensibilità verso i temi della SSL (media=4,35, su una scala variabile da 1=per niente importante a 5=del tutto importante), seguita dalle capacità relazionali (3,84), all'esperienza nel sindacato (3,70) e alle proprie competenze tecniche (3,56). Alla motivazione "indisponibilità di altri colleghi" viene dato un punteggio medio di 2,79.

La maggior parte degli intervistati (58,4%) dichiara una sostanziale soddisfazione (molto/del tutto soddisfatto)

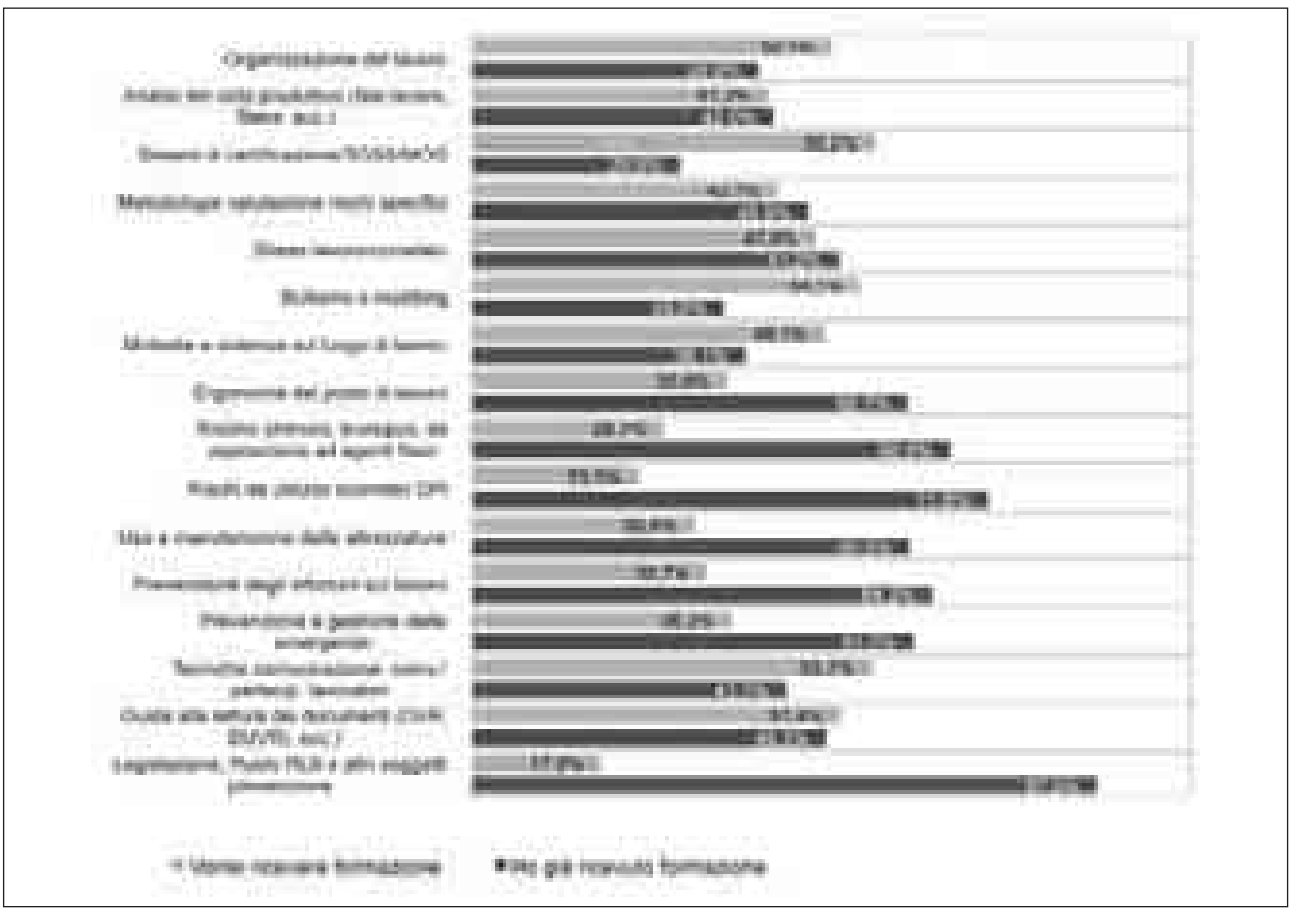

Figura 5. ***Distribuzione delle risposte su argomenti su cui i RLS hanno ricevuto o vorrebbero ricevere formazione. Valori percentuali***

rispetto al proprio ruolo nell'unità produttiva (Figura 6). Il livello di soddisfazione percepito varia in maniera significativa quando i dati vengono incrociati con la macro area geografica; in particolare, il 67,0% dei RLS afferenti a Sud e Isole si dichiara "molto/del tutto" soddisfatto, verso il 54,0% dichiarato dai RLS delle aziende del Nord.

Sulla base della propria esperienza, il 76,1% del campione ritiene utile un'estensione della durata del mandato (rispetto ai tre anni) per poter rafforzare il proprio ruolo.

Secondo l'opinione dei RLS, il proprio ruolo nella realtà produttiva in cui opera è considerato dai lavoratori principalmente di "riferimento per i lavoratori e loro "voce" in azienda in tema di SSL" (81,8%) e "potenzialmente importante, ma con scarse possibilità di operare efficacemente" (74,6%); solo il 19,4% dei RLS ritiene che i lavoratori della propria azienda lo considerano un "ruolo privilegiato" (Figura 7).

I risultati ottenuti in questa area tematica risultano associati con il settore economico. In particolare, la percentuale di RLS che pensa che i lavoratori giudichino quello dei RLS un ruolo "di riferimento per i lavoratori e loro "voce" in azienda in tema di SSL" risulta significativamente inferiore nella Sanità (70,5%) e nella Pubblica amministrazione (69,5%) rispetto all'80% circa registrato a totale campione.

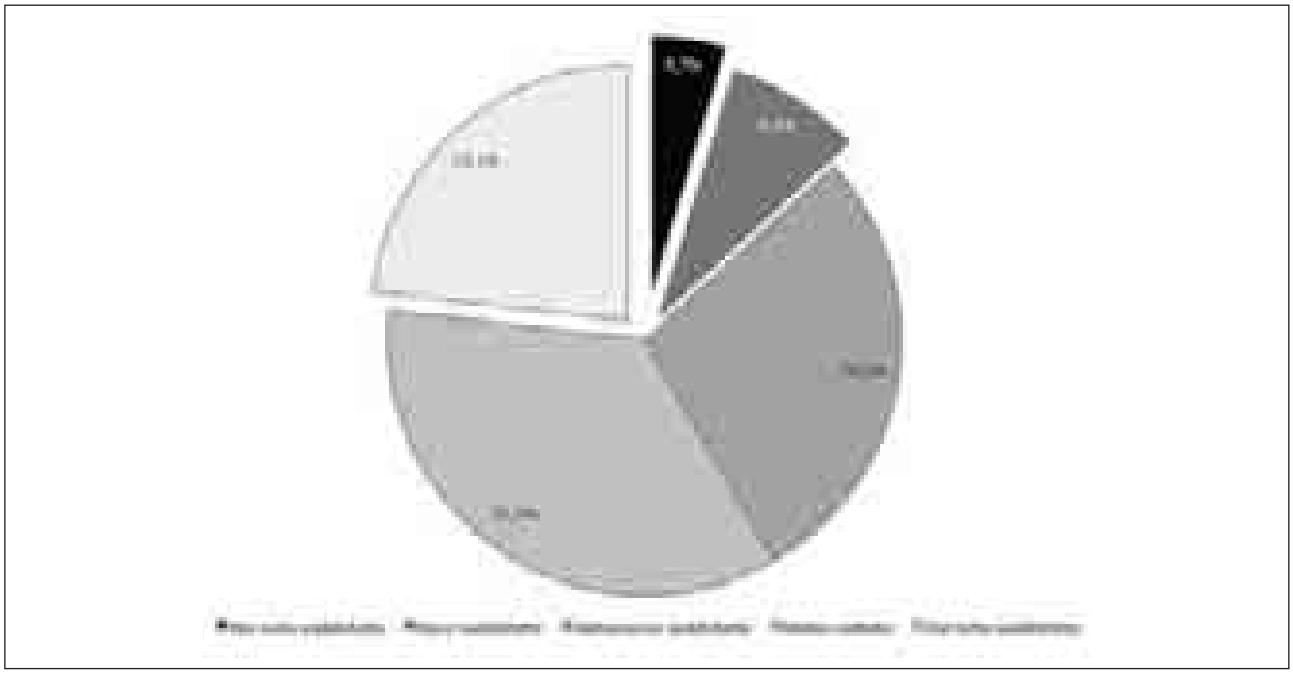

Figura 6. ***Grado di soddisfazione percepito nel ricoprire il ruolo di RLS. Valori Percentuali***

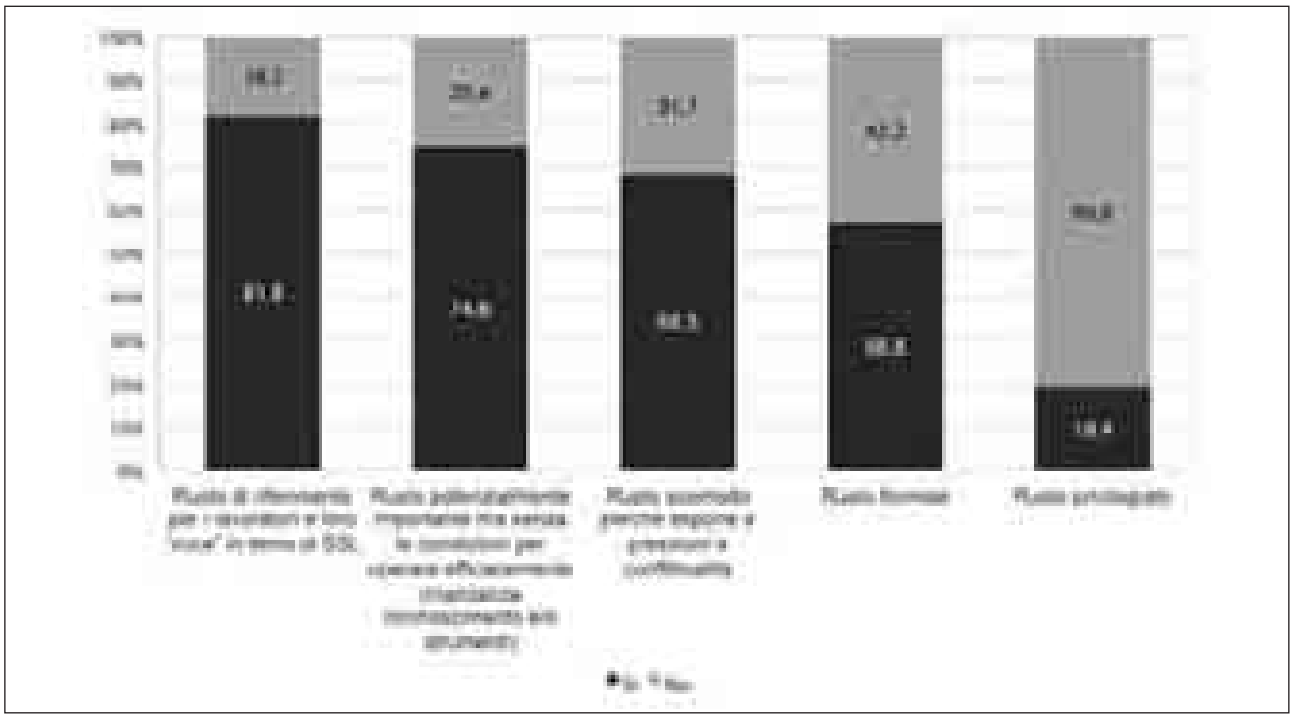

Figura 7. ***Percezione del RLS sul giudizio dei lavoratori dell'unità produttiva rispetto al ruolo di RLS. Valori percentuali***

Quando si chiede agli intervistati di indicare, su una scala variabile da 1=per niente a 5=molto, in che misura ritiene vadano migliorati alcuni ambiti, il punteggio medio maggiore viene attribuito alla "consapevolezza del rischio da parte dei lavoratori" (4,32), segue la formazione aggiuntiva oltre a quella minima (4,10) e il supporto esterno messo a disposizione dall'Organismo paritetico (4,02) (Figura 8).

Riguardo alla raccolta delle segnalazioni dei lavoratori, emergono differenze significative in base alla dimensione aziendale, secondo cui all'aumentare della stessa, diminuisce la necessità di miglioramento di tale aspetto legato al proprio ruolo. La formazione aggiuntiva richiede, inoltre, in misura maggiore miglioramenti secondo la percezione dei RLS afferenti alle aziende con 50-249 addetti, facendo registrare un punteggio medio di 4,24, verso il 3,78 rilevato nelle piccole aziende.

La necessità di migliorare l'acquisizione di informazioni e documentazione è maggiormente percepita dai RLS afferenti a commercio e trasporto (media=4,11 per entrambi i settori), alla pubblica amministrazione (4,05) e costruzioni (4,02); tale necessità è percepita meno, al contrario, in agricoltura (3,36), nelle attività professionali (3,62) e nei servizi di informazione/comunicazione per i quali si registra un valore di 3,77. Inoltre, le procedure aziendali per la raccolta delle segnalazioni dei lavoratori meritano una maggiore attenzione soprattutto secondo i RLS operanti nel settore del commercio (media=4,31) e delle costruzioni (media=4,14).

Lo studio sui RLST

Ai RLS Territoriali (RLST) è stato somministrato un questionario costruito ad hoc, per tener conto delle peculiarità di questa figura della prevenzione. Il campione intervistato, composto da 141 RLST, è costituito prevalentemente da uomini (82,6%), di età media 50,07 anni. Il 56,4% possiede il diploma di scuola media superiore/Attestato di qualifica professionale; la maggior parte (38,8%) svolgeva precedentemente l'attività di funzionario sindacale e il 40,3% operava come RLS aziendale; il 66,2% è impiegato in modalità Full-time, in media da 14,31 anni.

Il 68,1% dei RLST intervistati opera nel Nord Italia, in prevalenza nel Nord-Ovest (36,9%); afferiscono a organizzazioni di comparti diversi, soprattutto costruzioni (53,9%) e artigianato (45,4%). Tali figure sono meno diffuse all'interno dei comparti del commercio (9,9%), dell'industria (5,7%) e dell'agricoltura (5,0%). Le aziende per le quali i RLST svolgono la propria attività sono, per la maggior parte, realtà di piccole dimensioni: il 90,0% infatti, opera in unità produttive con meno di 10 dipendenti. Al 43,2% degli intervistati sono state assegnate fino a 100 aziende, il 29,2% ne segue oltre 300, mentre il 27,7% tra 101 e 300 aziende. Inoltre, il 36,6% del campione opera in 2 o più province del territorio; oltre il 65% percorre, in media, tra 51-150 chilometri al giorno e l'11,5% oltre 150 Km giornalieri per lo svolgimento della propria attività.

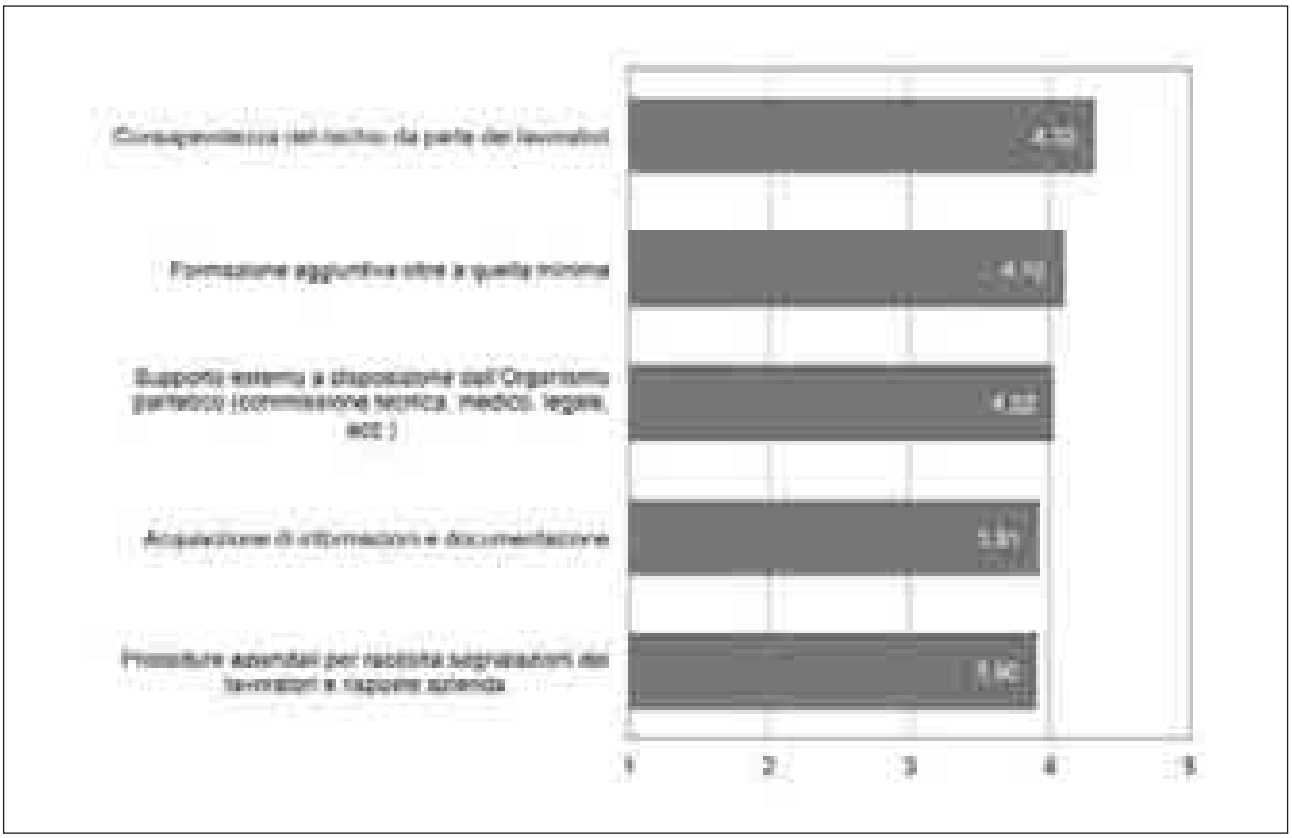

Figura 8. ***Giudizio del RLS sulla necessità di migliorare gli ambiti elencati. Valori medi (*)***

(*) scala variabile da 1=per niente a 5=molto

Rischi sul lavoro e condizioni di salute e sicurezza

Il campione intervistato ritiene di essere esposto - su una scala variabile tra 1 = non esposto e 5 = molto esposto - maggiormente a rischi legati a spostamenti e trasferte per lavoro (media = 3,81); seguono il rischio dovuto agli ambienti di lavoro che visita (2,37) e il rischio di aggressioni fisiche e/o verbali (2,06). Dove presenti, i rischi da interferenza sono efficacemente gestiti solo per poche aziende nell'ambito di quelle seguite (62,8%); solo nel 24,8% dei casi sono gestiti efficacemente per la maggior parte delle aziende seguite dai RLST intervistati. Le ragioni principali che possono contribuire a determinare un infortunio sono individuate nella mancanza di conoscenza e consapevolezza dei pericoli sul luogo di lavoro da parte dei lavoratori (media = 3,91), nelle procedure di lavoro inadeguate o mancanti (3,80) e nell'inadeguata adozione di misure di sicurezza da parte dei lavoratori (3,76); le fatalità difficilmente prevedibili risultano essere le motivazioni ritenute meno importanti dal campione (2,39).

Formazione su SSL

Gli intervistati hanno ricevuto in media 89,13 ore di formazione di base obbligatoria, 11,79 di aggiornamento obbligatorio nell'ultimo anno e 29,27 di formazione aggiuntiva oltre quella minima prevista. La modalità di erogazione della formazione ritenuta più efficace (molto/del tutto) è quella in aula con esercitazioni tecnico-pratiche (83,2%), seguita da quella in aula con lavori di gruppo (75,8%) e in aula con lezioni frontali (75,0%); mentre solo il 15,6% ritiene efficace la formazione e-learning.

Gli argomenti per i quali, più diffusamente, è già stata ricevuta la formazione riguardano le tematiche legate al ruolo di RLST e degli altri soggetti coinvolti nella prevenzione (nel 96,6% dei casi), seguono il ruolo e le funzioni degli Enti Bilaterali, Organismi paritetici, sindacati (82,8%), guida alla lettura dei documenti e dei rischi da utilizzo scorretto dei DPI (78,4% entrambe) e prevenzione degli infortuni (76,7%). Le tematiche su cui i RLST vorrebbero ricevere più formazione riguardano, invece, i temi inerenti ai sistemi di certificazione (SGSL) (46,5%), le tecniche di comunicazione (42,1%), bullismo o mobbing (38,6%), violenza sui luoghi di lavoro (36,0%) e analisi del ciclo produttivo (33,3%).

Ruolo del RLST

Nella maggior parte delle aziende dove opera il RLST, il primo contatto avviene per il 56,5% del campione su iniziativa del rappresentante stesso, per il 22,6% su iniziativa dell'azienda che contatta per prima il RLST e per il 13,7% di essi tramite il contatto con gli organismi paritetici. Il 75,6% del campione dichiara di elaborare la relazione annuale sulle sue attività e per il 64,8% di organizzare il proprio operato in maniera autonoma. Circa il 90% dei rispondenti sostiene di avere accesso ai luoghi di lavoro in tutte o nella maggior parte delle aziende in cui opera. Il 94,4% degli intervistati, in fase di sopralluogo, può visitare tutti gli ambienti di lavoro nella maggior parte delle aziende, nel 95,1% dei casi può verificare la presenza dei DPI, mentre nel 66,9% può avere un colloquio diretto con i lavoratori.

Riguardo alla possibilità di incontrare le altre figure della prevenzione, il 74,0% può incontrare il RSPP e solo il 17,7% il medico competente, figura che circa la metà del campione può incontrare solo in poche delle aziende in cui opera e addirittura il 34,7% in nessuna delle aziende seguite in qualità di RLST.

In generale i RLST, su una scala da 1 a 5, si dichiarano piuttosto soddisfatti nel ricoprire tale ruolo, raggiungendo un punteggio medio di 3,94, valore leggermente superiore rispetto alla soddisfazione media espressa dai RLS aziendali.

In base al giudizio degli intervistati, la consapevolezza del rischio da parte dei lavoratori risulta essere il principale aspetto da migliorare legato al proprio ruolo (media = 4,22, dove la misura del miglioramento viene indicata su una scala da 1 = per niente a 5 = molto); segue la considerazione del ruolo del RLST da parte delle aziende (4,00) e la formazione aggiuntiva oltre a quella minima (3,85). I tempi a disposizione per poter svolgere il proprio ruolo risulta essere la criticità che i RLST percepiscono come la meno importante tra quelle da migliorare (3,07).

Conclusioni

Il presente studio mostra alcuni risultati principali relativi alla seconda edizione dell'indagine IMPAcT-RLS, in particolare sui temi di percezione del rischio in azienda, ambiti formativi, bisogni e necessità di miglioramento nello svolgimento del ruolo del RLS. La ricerca rappresenta un esempio di *survey* periodica realizzata in Italia e indirizzata ad un campione rappresentativo di RLS, nonché utile strumento di studio e monitoraggio delle condizioni di lavoro nel nostro Paese, anche rispetto ai cambiamenti intervenuti e ai bisogni dei principali attori coinvolti nel sistema di prevenzione.

Dai risultati emerge che il rischio maggiormente avvertito dai lavoratori risulta essere lo stress lavoro-correlato, seguito dai rischi biomeccanici/ergonomici, fisici e da videoterminale. Il rischio da eventi naturali viene percepito come quello a cui i lavoratori si sentono meno esposti.

Condizione di disabilità/inabilità e stato di gravidanza risultano i fattori personali maggiormente considerati nella valutazione del rischio in azienda, soprattutto in quelle di grandi dimensioni.

Dallo studio emerge che la formazione dei RLS risulta essere ancora un ambito da migliorare: il 12,1% del campione, infatti, dichiara di non aver ricevuto gli aggiornamenti previsti nonostante sia stato eletto da più di un anno e quasi la metà di esso non ha svolto nell'ultimo anno ulteriori ore di formazione aggiuntiva su SSL, oltre a quella obbligatoria. Un riscontro sugli argomenti da approfondire ha fatto registrare i sistemi di certificazione SGSL, le tecniche di comunicazione, i temi su violenza, bullismo e mobbing come i principali indicati dagli intervistati.

Il giudizio dei lavoratori rispetto al ruolo di RLS in azienda viene percepito principalmente come "riferimento per i lavoratori e "voce" su tematiche su SSL, mentre oltre il 70% pensa che sia giudicato come "potenzialmente importante, ma con scarse possibilità di operare efficacemente".

La consapevolezza del rischio da parte dei lavoratori, la formazione aggiuntiva e supporto esterno da parte dell'Organismo paritetico sono i principali ambiti che necessitano di miglioramenti nello svolgimento dell'attività dei RLS.

In generale, il campione intervistato dichiara una sostanziale soddisfazione rispetto alla considerazione del proprio ruolo nell'unità produttiva, anche se ritiene utile un'estensione della durata del mandato.

Rispetto alle precedenti edizioni dell'indagine (15), permangono, comunque, alcune difficoltà che impediscono l'affermazione di un ruolo attivo e partecipativo di questa figura della prevenzione. Tale criticità viene rilevata in maniera molto diversa tra le varie realtà aziendali, soprattutto in base al settore di afferenza e alla dimensione aziendale. In ogni caso, lo studio evidenzia le opportunità fornite dall'ampliamento della consultazione e partecipazione attiva dei RLS e finalizzate al miglioramento dei livelli di salute e sicurezza in azienda.

Sebbene il focus sui RLST abbia in generale evidenziato caratteristiche in comune con i RLS aziendali, l'appartenenza a realtà di piccole dimensioni afferenti a comparti specifici (prevalentemente costruzioni e artigianato) determinano situazioni più critiche per i RLST rispetto ai RLS, sia sull'individuazione dei rischi che sulla gestione della SSL, confermando i risultati ottenuti nella prima edizione dell'indagine IMPACT-RLS (15).

Uno dei limiti dello studio riguarda la metodologia di campionamento che consiste nella individuazione della popolazione di RLS partendo dalle liste afferenti alle principali sigle sindacali nazionali (Cgil, Cisl e Uil) con aggiustamenti finalizzati al raggiungimento della popolazione target fissata dai requisiti normativi del D.Lgs. 81/08 e s.m.i.

Al fine di includere anche i RLS di emanazione non sindacale, nell'ambito della nuova indagine INAIL INSuLa 2 del 2019, indirizzata ai datori di lavoro, è stato chiesto di indicare se nella propria azienda il RLS sia stato nominato\eletto nell'ambito delle rappresentanze sindacali o meno. Dalle prime analisi emerge che, in circa la metà dei casi, il RLS non è stato nominato/eletto nell'ambito di tali rappresentanze, prevalentemente nelle micro-piccole aziende (16). Sulla base di questo risultato, nella prossima rilevazione, potrà essere esplorata la possibilità di raggiungere anche questa parte del campione con iniziative mirate all'individuazione del contatto del RLS aziendale per la partecipazione all'indagine, in un'ottica di ottimizzazione dell'universo di riferimento e ulteriore miglioramento della rappresentatività del campione di IMPACT RLS. In conclusione, queste prime evidenze forniscono spunti interessanti per approfondimenti soprattutto riguardo le necessità e i bisogni manifestati dal RLS nello svolgimento del proprio ruolo. Quest'ultimo aspetto risulta di grande rilevanza soprattutto nella fase attuale caratterizzata da forti cambiamenti del mercato del lavoro, in cui la figura del RLS dovrebbe essere sempre più a supporto dei lavoratori per contribuire a fronteggiare tali situazioni in continua evoluzione.

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MEDICINA DEL LAVORO

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Il nuovo protocollo diagnostico Maugeri per stress lavoro-correlato e mobbing (MaSD-2)

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RIASSUNTO. Lo stress occupazionale può superare le capacità individuali d'adattamento dei lavoratori e causare quadri psicopatologici, tra cui il disturbo dell'adattamento (DA) e il disturbo post-traumatico da stress (DPTS), per i quali è obbligatoria la denuncia ex DM 10 giugno 2014. Dai primi anni del 2000, è in uso presso il nostro Istituto un protocollo diagnostico interdisciplinare che consente di orientare i pazienti verso un adeguato percorso terapeutico, al fine di favorire il loro benessere psicologico e la reintegrazione nel mondo del lavoro. Nel 2017 il protocollo è stato aggiornato e ampliato. La versione attuale (MaSD-2) comprende: visita di medicina del lavoro, colloquio psicologico, visita psichiatrica e test psicodiagnostici: *Short-Negative Acts Questionnaire* (S-NAQ), *Cognitive Behavioral Assessment 2.0* (CBA-2.0), SCID (*Structured Clinical Interview for DSM: Diagnostic and Statistical Manual of Mental Disorders*), *Minnesota Multiphasic Personality Inventory-2-Restructured Form* (MMPI-2-RF), *Maugeri Stress Index – Reduced form* (MASI-R).
Nel triennio 2017-2019 sono stati valutati con il MaSD-2 198 pazienti (120 donne e 78 uomini; età media ± DS: 47,9 ± 9,0 anni) che riferivano problemi di salute da loro attribuiti a vessazioni subite in ambito lavorativo o ad altre forme di stress occupazionale. Nove (4,5%), già esaminati con la versione originaria del protocollo, hanno ricevuto conferma diagnostica (2 casi di disturbo paranoide di personalità, 7 di disturbo ansioso-depressivo lavoro-correlato). Degli altri 189 soggetti, 3 (1,6%) non risultavano affetti da patologia psichiatrica, 12 (6,3%) presentavano un disturbo psichiatrico (es. disturbo d'ansia, disturbo dell'umore, disturbo di personalità) indipendente dal lavoro, 160 (84,7%) un disturbo ansioso e/o depressivo correlato al lavoro. In 12 casi (6,3%) si è posta diagnosi di DA e in 2 (1,1%) di DA in pregresso DPTS, per un totale di 14 segnalazioni di malattia professionale alle Autorità competenti. Rispetto al passato, la casistica presenta una percentuale molto maggiore di disturbi psichiatrici correlati a stress occupazionale. Questo può dipendere da una maggiore sensibilità del nuovo protocollo diagnostico e da una migliore selezione dei pazienti che ci vengono inviati. Le donne e i lavoratori del terziario continuano a essere a maggior rischio, con significativo coinvolgimento degli operatori sanitari. Rimangono rare le diagnosi di DA e DPTS, confermando la necessità di un rigoroso e prudente percorso interdisciplinare, volto a selezionare i casi per i quali avviare procedure medico-legali. Lo studio richiama infine la necessità di adeguate misure preventive.

Parole chiave: stress lavorativo, salute mentale, disturbo dell'adattamento, disturbo post-traumatico da stress, valutazione psicologica.

Stress lavoro-correlato e mobbing

Lo stress può essere definito come lo stato di disagio psichico che può insorgere quando l'ambiente esterno pone richieste e oneri che sollecitano l'individuo a fornire prestazioni superiori al normale, quantitativamente o qualitativamente (1). Tale situazione può spesso verificarsi nel mondo del lavoro: si parla in questo caso di stress lavoro-correlato, definito dall'Organizzazione Mondiale della sanità (OMS) come "la percezione di squilibrio avvertita dal lavoratore quando le richieste del contenuto, dell'organizzazione e dell'ambiente di lavoro eccedono le capacità individuali per fronteggiare le richieste" (2).

Le condizioni e le forme di organizzazione del lavoro che possono essere all'origine di situazioni stressanti sono molteplici; esse comprendono: carichi di lavoro e di responsabilità eccessivi o, di converso, troppo scarsi; eccessiva rigidità o variabilità dei compiti; conflitti interpersonali; ripetitività e monotonia, soprattutto se associate alla necessità di un elevato livello di vigilanza, attenzione e concentrazione; lavoro a turni, lavoro notturno; fattori ambientali disturbanti (es.: rumore, odori, microclima) (3).

Entro certi limiti, ciascun individuo è in grado di adattarsi a situazioni stressanti e di fornire le prestazioni richieste senza danni alla salute. Spesso la necessità di fornire una determinata prestazione (volta al conseguimento di un risultato prefissato) è utile al lavoratore, in quanto rappresenta proprio lo stimolo adatto a fornire la performance richiesta: si parla in questo caso di eustress (stress "buono"). Quando tuttavia i limiti individuali (assai variabili) sono superati, il rendimento lavorativo e la gratificazione personale diminuiscono e possono insorgere manifestazioni patologiche: distress (stress "cattivo"). La "sindrome da stress" comprende manifestazioni emozionali (tipicamente ansia, ma anche depressione con crisi di pianto, irritabilità con accessi d'ira, attacchi di panico), comportamentali (atteggiamenti di fuga dal lavoro; disturbi alimentari, sessuali, del sonno; abuso di sostanze; abulia, incapacità di reagire; difficoltà interpersonali, aggressività) e psicosomatiche (malessere generale, cefalea, disturbi digestivi e cardiovascolari, immunodepressione con aumentato rischio infettivo e neoplastico) (4).

Una forma di stress lavorativo particolarmente grave è il mobbing (a volte detto bullismo), termine con il quale si

ABSTRACT. The new Maugeri diagnostic protocol for work-related stress and mobbing (MaSD-2). ***Occupational stress can exceed the workers' individual capacity to adapt, and cause psychopathological conditions, including adjustment disorder (AD) and post-traumatic stress disorder (PTSD), for which medico-legal reporting is mandatory by law. Since the early 2000s, an interdisciplinary diagnostic protocol has been in use at our Institute to address patients towards an appropriate therapeutic path, in order to promote their psychological well-being and work reintegration. In 2017, the protocol was updated and expanded. The current version (MaSD-2) includes: occupational medicine examination, psychological counselling, psychiatric interview, and psychodiagnostic testing: Short-Negative Acts Questionnaire (S-NAQ), Cognitive Behavioral Assessment 2.0 (CBA-2.0), SCID (Structured Clinical Interview for DSM: Diagnostic and Statistical Manual of Mental Disorders), Minnesota Multiphasic Personality Inventory-2-Restructured Form (MMPI-2-RF), Maugeri Stress Index – Reduced form (MASI-R). Between 2017 and 2019, we used the MaSD-2 to assess, for suspected psychopathological work-related problems, 198 patients (120 women and 78 men; mean age ± SD: 47.9 ± 9.0 years). Nine (4.5%), already examined with the original version of the protocol, received diagnostic confirmation (2 cases of paranoid personality disorder, 7 of work-related anxiety-depressive disorder). Of the other 189 subjects, three (1.6%) were not affected by psychiatric disease, 12 (6.3%) had a psychiatric disorder (e.g., anxiety disorder, mood disorder, personality disorder) independent of work, 160 (84.7%) a work-related anxiety and/or depressive disorder. DA was identified in 12 cases (6.3%), and two patients (1.1%) were diagnosed with DA in pre-existent DPTS, for a total of 14 medico-legal reports of occupational disease. Compared to the past, the case record presents a much higher percentage of psychiatric disorders related to occupational stress. This may be due to a greater sensitivity of the new diagnostic protocol, and to a better selection of the patients referred to us. Women and tertiary workers continue to be at greater risk, with significant involvement of health professionals. Diagnoses of DA and DPTS remain rare, confirming the need for a rigorous and cautious interdisciplinary approach, aimed at selecting the cases for which to start medico-legal procedures. Finally, the study calls for adequate preventive measures.***

Key words: *occupational stress, mental health, adjustment disorder, post-traumatic stress disorder, psychological assessment.*

fa riferimento a molestie psicologiche, quasi sempre intenzionali, ripetute e prolungate nei confronti di un lavoratore, dovute ad azioni ostili condotte solitamente dal superiore o da un piccolo gruppo di colleghi, esercitate attraverso comportamenti aggressivi, persecutori e lesivi della dignità personale e professionale, in grado di provocare danni alla salute psicofisica individuale (5). In tempi recenti, su tale fenomeno si è sviluppata una ricca letteratura scientifica che ha classificato le tipologie di mobbing (verticale, orizzontale o trasversale; pianificato o strategico, emozionale o relazionale), definito i fattori di rischio (legati all'azienda e all'individuo) e identificato le modalità d'attacco (alla comunicazione, alla reputazione e alle prestazioni) (6). Il mobbing può avere conseguenze devastanti sulla salute di chi lo subisce, anche a lungo termine, ossia anni dopo che la vittima si è allontanata dall'ambiente patogeno (7).

La patologia (o sindrome) da mobbing può essere considerata la variante più grave della sindrome da stress. Deve essere tuttavia ricordato che, nella pratica clinica e certificativa, può risultare assai difficile, basandosi solo su quanto riferito dal lavoratore, distinguere il mobbing dalle altre forme di stress lavoro-correlato. Ad esempio, non sono mobbing l'antagonismo e la competitività tra colleghi, le liti e i conflitti occasionali, le antipatie personali, le richieste di cambiamento per esigenze aziendali, i provvedimenti disciplinari motivati.

Aspetti diagnostici e medico-legali

La sindrome da stress e la patologia da mobbing non sono chiaramente identificate dal punto di vista nosologico. In particolare, esse non sono contemplate né dall'*International Classification of Diseases* (ICD-11) né dal *Diagnostical and Statistical Manual of Mental Disorders* (DSM-5). ICD-11 e DSM-5 individuano solo due condizioni psichiatriche che si possono verificare come risposta a eventi stressanti (non necessariamente in ambito lavorativo): il *Disturbo dell'Adattamento* (DA) e il *Disturbo Post-Traumatico da Stress* (DPTS) (8, 9).

Il DA si verifica in risposta a un fattore di stress in cui un certo numero di cambiamenti della vita agiscono come precipitanti. La persona mostra un marcato disagio o compromissione del funzionamento (incapacità di lavorare o svolgere altre attività). Per formulare questa diagnosi, i sintomi devono manifestarsi entro tre mesi dall'inizio del fattore stressante. La reazione deve essere sproporzionata rispetto alla natura dello stress oppure vi deve essere una significativa compromissione del funzionamento sociale o lavorativo. Non si deve porre diagnosi di DA se la reazione soddisfa i criteri per un altro specifico disturbo d'ansia o dell'umore. I sintomi del disturbo di solito si risolvono entro sei mesi (*disturbo di adattamento acuto*), benché possano durare più a lungo se prodotti da un fattore stressante cronico o che abbia conseguenze persistenti (*disturbo di adattamento cronico*) (9, 10).

Il DPTS (diagnosi assai più rara) è un disturbo transitorio che può insorgere in soggetti che abbiano vissuto o che abbiano assistito a un evento traumatico che ha implicato un rischio per l'integrità fisica o per la vita, propria o di altre persone come, ad esempio, aggressioni personali, disastri, guerre e combattimenti, rapimenti, torture, incidenti, violenze, malattie gravi. I principali sintomi possono essere raggruppati in tre specie: (i) frequenti immagini e pensieri intrusivi, flashback o incubi ricorrenti che fanno rivivere l'evento traumatico (la riesperienza del trauma può verificarsi in qualunque momento: di solito compare con maggior probabilità quando la persona si trova in situazioni che ricordano il trauma, ma spesso si manifesta anche in circostanze insospettabili; l'elemento scatenante può essere anche soltanto un colore, un odore o un suono); (ii) comportamenti persistenti di evitamento di circostanze associabili al trauma, come luoghi, attività o persone che fanno ricordare l'evento traumatico (questi comportamenti possono essere associati a una sensazione di disagio invalidante, che va ben al di là della comune preoccupazione vissuta dalla maggior parte delle persone quando, ad esempio, si cerca di ricominciare a guidare

l'automobile dopo un incidente stradale, e che può essere scatenato anche dal semplice rumore di una frenata, dal suono di un clacson o dalle luci dei fari in movimento); (iii) sintomi persistenti di sovra-eccitamento (ad esempio, irritabilità, preoccupazione, ansia, depressione, insonnia, difficoltà di concentrazione *etc*.) (9, 11).

Deve essere sottolineato che la diagnosi di DA acuto e di DPTS (disordini psichiatrici conseguenti generalmente a eventi di breve durata) mal si adattano ai casi di patologia da mobbing che, per definizione, è una situazione stressante reiterata. Secondo Leymann, infatti, le vessazioni debbono ricorrere con una determinata frequenza (statisticamente almeno una volta alla settimana) e nell'arco di un lungo periodo di tempo (almeno sei mesi) (5). È stato pertanto proposto di utilizzare l'espressione *Prolonged Stress Disorder* che però non è ricompresa nell'ICD-11 o nel DSM-5 (2).

Le "malattie psichiche e psicosomatiche da disfunzioni nell'organizzazione del lavoro" sono incluse nell'elenco delle malattie per le quali è obbligatoria la denuncia (Decreto 10 giugno 2014 del Ministero del Lavoro e delle Politiche Sociali: lista II, gruppo 7), in tale elenco sono compresi il "disturbo dell'adattamento cronico" e il "disturbo post-traumatico da stress", a cui pertanto occorre fare esclusivo riferimento per la diagnosi medico-legale di disturbo psichico da costrittività organizzativa sul lavoro, con le conseguenti ricadute in ambito penale, civile e assicurativo.

L'accurato inquadramento diagnostico dei quadri psicopatologici sopra descritti è dunque importante non solo ai fini clinici, ma anche per l'eventuale dimostrazione del nesso di causa tra lo stress cui è stato esposto il lavoratore (nei casi di mobbing, le vessazioni subite) e il danno patito (12, 13). Per tale motivo – e in considerazione delle crescenti richieste da parte dell'utenza – i centri specialistici di medicina del lavoro hanno perfezionato nel corso degli ultimi anni protocolli diagnostici interdisciplinari più o meno complessi, comprendenti la somministrazione di specifici questionari (14-17).

Presso l'Istituto di Pavia di ICS Maugeri (convenzionato con la locale Università) è stato attivato, nei primi anni del Duemila, un percorso valutativo comprendente inizialmente: accurata anamnesi (anche sociale e lavorativa), esame obiettivo, colloquio clinico-psicologico, test di personalità (SCID: *Structured Clinical Interview for DSM-IV*), asse I e II; MMPI-2: *Minnesota Multiphasic Personality Inventory-2*, visita psichiatrica, eventuali accertamenti (laboratoristici e strumentali) per patologie d'organo (13, 18). Con questo protocollo sono stati esaminati quasi 900 pazienti che, nel corso degli anni, hanno richiesto aiuto per problemi psicopatologici connessi, a giudizio dei pazienti stessi, a mobbing o altre forme di costrittività organizzativa in ambito lavorativo. Al termine del percorso diagnostico, un disturbo psichiatrico correlato al lavoro (in genere, disturbo d'ansia) è stato riscontrato solo in circa la metà di essi. Nell'altra metà del campione, non è stato possibile formulare una psicodiagnosi secondo i criteri del DSM o è stato identificato un disordine psichiatrico non lavoro-correlato. Una sindrome psichiatrica (DA o DPTS) correlabile a mobbing è stata diagnosticata in meno del 10% dei casi (13, 19).

Tali dati confermano come un approccio scientifico nell'inquadramento diagnostico (necessariamente interdisciplinare) della patologia da stress lavoro-correlato sia di fondamentale importanza per una corretta stima della reale incidenza del fenomeno e per consentire un adeguato riconoscimento in ambito medico-legale e assicurativo (20, 21). Soprattutto, la nostra casistica è un richiamo alla prudenza nell'etichettare come "sindrome da mobbing" situazioni cliniche che tali non sono. In proposito, è sicuramente rilevante l'elevato riscontro di patologie psichiatriche indipendenti dall'attività lavorativa. Come richiamato anche nella letteratura scientifica internazionale (22), tali condizioni, se valutate superficialmente senza i necessari approfondimenti diagnostici, possono facilmente generare contenziosi con i datori di lavoro basati su accuse infondate. Tali contenziosi, peraltro, possono a loro volta causare aggravamenti del quadro clinico preesistente.

Occorre inoltre considerare che, anche nei casi identificati come patologia da mobbing (e come tali segnalati alle competenti Autorità), la diagnosi è stata probabilistica e in buona parte basata su quanto anamnesticamente riferito dai pazienti, in quanto al nostro servizio ambulatoriale manca la possibilità di verificare direttamente l'eventuale esistenza di un clima vessatorio nell'ambiente di lavoro, compito tra l'altro assai arduo e per il quale tuttora non esistono metodiche sufficientemente validate (12, 21).

Aspetti normativi e preventivi

Le conseguenze negative dello stress lavorativo sulle condizioni psicofisiche del lavoratore sono note da tempo e documentate anche nella letteratura non scientifica e nel mondo dell'arte[1]. Nel passato, tuttavia, l'attenzione dei medici del lavoro e dei legislatori era distolta da altri gravi problemi (si pensi ad esempio alle pneumoconiosi e alle intossicazioni professionali). In tempi recenti, il problema è diventato prioritario con l'emanazione del D.lgs. 81/2008 che, all'art. 28, sancisce che la valutazione dei rischi (indispensabile premessa a eventuali interventi preventivi) deve comprendere «anche quelli collegati allo stress lavoro-correlato». Rispetto ai rischi professionali "classici", la problematica è particolarmente accentuata perché la valutazione implica necessariamente un giudizio sull'organizzazione del lavoro, che costituisce il cuore di ogni azienda. Inoltre, la natura dei fattori di rischio, diverso da altri (es. rumore, agenti chimici) affrontabili con metodi e strumenti di misura standardizzati, richiede l'applicazione di una metodologia condivisa da tutti i soggetti interessati (compresi i lavoratori) ma – soprattutto – dal datore di lavoro e dai vertici aziendali (23).

[1] In ambito cinematografico, ad esempio, si possono ricordare il celeberrimo "Tempi moderni" (*Modern Times*), film statunitense del 1936 scritto, diretto e interpretato da Charlie Chaplin e, più recentemente (2003), "Mi piace lavorare (Mobbing)", film prodotto e diretto da Francesca Comencini, con Nicoletta Braschi e un cast di attori non professionisti.

La letteratura scientifica propone numerosi metodi "soggettivi", in genere sotto forma di questionari, che permettono di rilevare la percezione da parte dei singoli lavoratori delle caratteristiche dell'organizzazione del lavoro e degli effetti di situazioni occupazionali stressogene. Tali metodi presentano i vantaggi della rapidità e del basso costo ma non consentono di cogliere in quale misura gli indicatori di stress identificati attraverso le percezioni dei lavoratori riflettano realmente le effettive condizioni di lavoro (le risposte fornite potrebbero essere più o meno intenzionalmente distorte, oppure le situazioni di stress denunciate potrebbero trarre origine da fattori extralavorativi). Inoltre, i metodi soggettivi implicano la somministrazione dello strumento d'indagine a tutti i lavoratori dell'azienda o a campioni significativamente numerosi. Sarebbe dunque preferibile condurre l'indagine mediante metodi di valutazione "oggettivi": questo significa organizzare una squadra di valutatori, alla quale partecipano lavoratori "esperti" che conoscono a fondo la realtà aziendale (24).

Secondo le indicazioni metodologiche della Commissione consultiva permanente per la salute e la sicurezza sul lavoro, la valutazione del rischio stress lavoro-correlato si articola in due fasi. La prima fase (valutazione preliminare) prende in esame quali indicatori elementi oggettivi e verificabili e fattori di rischio attinenti l'organizzazione aziendale: eventi sentinella (es. indici infortunistici, assenze per malattia, turnover), fattori di contenuto del lavoro (es. carichi e ritmi, orari e turni), fattori di contesto del lavoro (es. autonomia decisionale, conflitti interpersonali). Se non emergono elementi di rischio tali da richiedere azioni correttive, si attua solo un piano di monitoraggio. In caso contrario, si procede alla pianificazione e all'adozione degli opportuni interventi (formativi, organizzativi, tecnici, procedurali etc.).

Ove gli interventi correttivi risultino inefficaci, si procede alla seconda fase della valutazione (rilevazione della soggettività), attraverso metodi d'indagine che possono comprendere questionari, focus group, interviste semistrutturate. Tale fase è condotta sui gruppi omogenei di lavoratori per i quali sono state rilevate problematiche (23).

Il MaSD-2

Significato dell'acronimo

Il protocollo diagnostico inizialmente adottato presso il nostro Istituto, descritto per la prima volta in dettaglio nel 2004 (18), dall'anno 2017 è stato aggiornato e ampliato con l'introduzione di ulteriori test. Riteniamo pertanto opportuno descrivere la versione attuale. Essa è stata denominata con l'acronimo "MaSD", derivante dalle iniziali di "Maugeri", "Stress" e "Diagnosi", con l'aggiunta del numero 2 per distinguerla dalla versione originaria.

Accoglienza e ambientazione

I soggetti che cercano aiuto medico per problemi psicopatologici di possibile origine lavorativa si trovano spesso in stato di evidente disagio emotivo, e possono manifestare diffidenza e ostilità. Molti di loro sono in malattia e/o hanno in corso contenziosi legali con il datore di lavoro (non è infatti raro che si rivolgano a noi su consiglio dell'avvocato). Per questo motivo, sin dal primo contatto telefonico essi sono seguiti con particolare tatto ed empatia, e informati circa contenuto, finalità e tempistica del protocollo. Inoltre, i pazienti sono avvisati che le conclusioni diagnostiche potrebbero non combaciare con le loro aspettative, e che un'eventuale diagnosi di malattia professionale comporta ineludibili adempimenti medico-legali (referto all'Autorità giudiziaria, denuncia all'Organo di Vigilanza e all'Ispettorato del Lavoro, certificazione INAIL).

La tutela della riservatezza e della privacy è, ovviamente, di fondamentale importanza. Colloqui, visite e test sono condotti alla presenza di non più di due operatori (medico, infermiere e/o psicologo), in ambiente silenzioso e confortevole.

Visita di medicina del lavoro

Comprende accurata anamnesi (familiare e personale; fisiologica e patologica, remota e prossima) ed esame obiettivo completo (25). Di fatto è assimilabile a una visita internistica (approccio olistico), con particolare attenzione alla storia lavorativa, raccolta in ordine cronologico, partendo cioè dai tempi più remoti («A che età ha iniziato a lavorare?») per giungere alla descrizione dell'occupazione attuale, tentando d'identificare gli agenti stressanti e altri fattori professionali di rischio che possono avere svolto un ruolo causale nel quadro clinico giunto all'osservazione (26).

Di regola in questa fase (che non dura mai meno di due ore) il paziente, superato l'inevitabile impaccio iniziale, si dilunga a descrivere fatti e circostanze (lavorativi e non solo), spesso dando libero sfogo alle proprie emozioni. È assai frequente che fornisca documentazione, talora copiosa, relativa sia a precedenti accertamenti medici e psicologici, sia a presunte vessazioni o ingiustizie patite (diari, lettere, e-mail, registrazioni), ponendo all'esaminatore il non facile compito di identificare e allegare in cartella quello che potrebbe risultare utile ai fini diagnostici.

Dalla visita del medico del lavoro può scaturire l'indicazione per esami strumentali e di laboratorio, e/o per altre consulenze specialistiche (ad es. visita cardiologica o endocrinologica), finalizzati alla diagnostica di patologie d'organo. Come accennato sopra, infatti, la "sindrome da stress" può indurre disturbi a componente psicosomatica (es. ulcera peptica, ipertensione arteriosa) che possono porre insidiosi problemi diagnostici differenziali; di converso, sintomi neuropsichiatrici possono manifestarsi in diverse malattie internistiche (quali, tipicamente, le tireopatie) (27).

Short-Negative Acts Questionnaire (S-NAQ)

Lo S-NAQ è uno strumento psicometrico validato e facile da usare per identificare soggetti esposti a vari gradi di bullismo sul luogo di lavoro (28). Consiste in nove domande su specifici comportamenti negativi, che misurano l'esposizione alle molestie negli ultimi sei mesi. I pazienti valutano la frequenza di ciascun atto negativo in base alle seguenti categorie di risposta: 1-Mai, 2-Di tanto in tanto, 3-Mensilmente, 4-Settimanalmente, 5-Quotidianamente.

***Cognitive Behavioral Assessment 2.0* (CBA-2.0)**

Il CBA 2.0, versione riveduta e aggiornata del CBA 1.0, è una batteria di test psicometrici composta da dieci schede (scale primarie), ciascuna comprendente item omogenei per aspetto formale o per derivazione storica, che vanno a sondare uno specifico aspetto del soggetto (29).

Le schede 1 e 4 sono cartelle autobiografiche che indagano la storia educativa e scolastica, le condizioni di convivenza attuali, le relazioni affettive significative ed eventuali problemi, lo stato di salute generale, le abitudini alimentari e del sonno, i disturbi o problemi psicologici lamentati e la motivazione a un eventuale trattamento psicologico. Le schede 2 (20 item), 3 (20 item) e 10 (10 item) valutano l'ansia. La scheda 5 (48 item), valuta alcune dimensioni stabili della personalità quali introversione-estroversione, stabilità emozionale, disadattamento e antisocialità, simulazione e ingenuità sociale. La scheda 6 (30 item) fornisce la valutazione dello stress e dei disturbi psicofisiologici. La scheda 7 (58 item) valuta le paure. La scheda 8 (24 item) valuta gli eventuali sintomi depressivi. La scheda 9 (21 item), infine, analizza le ossessioni e le compulsioni (30).

In base all'analisi delle risposte, effettuata con l'ausilio di un apposito programma informatico, è possibile formulare ipotesi diagnostiche in base alle quali somministrare scale secondarie per ulteriori approfondimenti (29).

***Structured Clinical Interview for DSM* (SCID)**

Il Manuale diagnostico e statistico dei disturbi mentali (DSM: *Diagnostic and Statistical Manual of Mental Disorders*), giunto attualmente alla quinta edizione, è il sistema nosografico più utilizzato per i disturbi psicopatologici, sia nella pratica clinica sia nell'ambito della ricerca (9).

Il nostro protocollo prevede la somministrazione dello SCID asse II, volto a indagare i disturbi di personalità. Lo strumento è costituito da un questionario di autovalutazione e da una successiva intervista relativamente alle risposte positive del questionario. La somministrazione richiede abitualmente 30-60 minuti.

In casi selezionati è associato lo SCID asse I, utile per diagnosticare i disturbi psichiatrici maggiori. Si tratta di un'intervista che deve essere somministrata da un operatore esperto e che può richiedere fino a due ore.

***Minnesota Multiphasic Personality Inventory-2-Restructured Form* (MMPI-2-RF)**

Il MMPI-2-RF è la versione più recente del test psicodiagnostico più utilizzato al mondo per valutare la personalità e la psicopatologia. Si articola su 51 scale, validate anche per la popolazione italiana. La nuova forma riduce notevolmente i tempi di somministrazione, in quanto il numero degli item (con risposta "vero/falso") del questionario è sceso da 567 (MMPI-2) a 338. Il test include scale "di validità" che consentono di determinare se i risultati sono interpretabili e, in generale, l'atteggiamento del soggetto di fronte al test. Benché il MMPI-2R sia nato in un contesto clinico, grazie al fatto che esso può studiare caratteristiche sia normali sia patologiche di personalità, la sua somministrazione si è rivelata assai utile anche in ambito occupazionale e forense (31).

***Maugeri Stress Index – reduced form* (MASI-R)**

Il MASI-R, versione ridotta del *Maugeri Stress Index questionnaire* (32), è un questionario multidimensionale che valuta la percezione soggettiva dello stress lavoro-correlato. Esso è composto da 37 item con risposta su scala Likert da 0 a 5 e da due analoghi visivi graduati 0-100. Lo strumento è formato da quattro scale [*Benessere* (7 item), *Resilienza* (16 item), *Supporto sociale* (5 item), e *Coping* (5 item)] e da una scala di controllo *Lie* (4 item).

La prima scala descrive una condizione psichica positiva, caratterizzata da energia, soddisfazione e ottimismo. La seconda indaga costrutti di resilienza, autoefficacia e *locus of control* interno, ossia risorse che facilitano l'adattamento a richieste e problemi dell'ambito lavorativo. La terza raggruppa descrizioni della percezione di potere utilizzare o ricevere supporto da colleghi e/o superiori. Nella quarta scala, minore è il punteggio maggiori sono gli aspetti di fragilità personale nell'affrontare lo stress, che si manifestano con stili di coping maladattativi o comportamenti disfunzionali.

I due analoghi visivi chiedono al soggetto di esprimere una valutazione della soddisfazione in ambito lavorativo (Analogo A) ed extra-lavorativo (Analogo B), consentendo in tal modo di esprimere un confronto fra queste due importanti aree della propria vita.

Studi di validazione (effettuati soprattutto su operatori sanitari) hanno dimostrato che il MASI-R è uno strumento affidabile e sensibile, oltre che dotato di buone capacità discriminanti, per l'identificazione precoce di situazioni di distress (33, 34).

Colloquio psicologico

Al termine dei test, in genere il giorno stesso, il paziente incontra uno psicologo clinico con esperienza specifica nel campo della psicologia del lavoro, allo scopo di approfondire la conoscenza delle sue dinamiche interpersonali e di delinearne la struttura della personalità. Il colloquio è prevalentemente incentrato sulle problematiche lavorative, senza trascurare di esplorare la vita familiare e sociale.

Il colloquio psicologico fornisce inoltre la possibilità di rivalutare criticamente le risposte fornite dal soggetto ai test psicometrici.

Visita psichiatrica

Comprende anamnesi psichiatrica (familiare e personale) e valutazione dello stato mentale (discorso, espressività emotiva, pensiero e percezione, funzioni cognitive). Le risposte ai test psicologici sono nuovamente discusse. La visita è principalmente finalizzata all'individuazione di eventuali sintomi psichiatrici correlabili allo stress lavorativo, ma anche a individuare disturbi psicopatologici preesistenti o comunque indipendenti dal lavoro. Le psicodiagnosi sono formulate con i criteri del DSM-5.

Valutazione conclusiva

Scaturisce dall'analisi critica di tutti i dati raccolti durante l'iter sopra descritto. Nei casi (in realtà eccezionali) in cui dovessero emergere discordanze di giudizio tra le

tre figure specialistiche (medico del lavoro, psicologo, psichiatra) coinvolte nel percorso valutativo, il caso è discusso collegialmente fino al raggiungimento di conclusioni diagnostiche condivise.

Al paziente è consegnato un referto contenente la descrizione dettagliata degli accertamenti eseguiti, le conclusioni diagnostiche, eventuali indicazioni per la terapia e il follow-up (farmaci e psicoterapia) e consigli finalizzati alla prosecuzione dell'attività lavorativa. Se necessario, il soggetto è indirizzato ai servizi psichiatrici territoriali.

I casi lavoro-correlati di disturbo dell'adattamento e di disturbo post-traumatico da stress sono segnalati alle competenti Autorità (Procura della Repubblica, Organo di Vigilanza, Ispettorato del Lavoro, INAIL).

Casistica

Lo studio è stato condotto con il consenso informato dei pazienti, secondo i criteri della Dichiarazione di Helsinki (35).

Il MaSD-2 è stato introdotto nella pratica ambulatoriale Maugeri nel 2017. Dall'inizio di tale anno a tutto il 2019 sono stati valutati con questo strumento diagnostico 198 pazienti (120 donne e 78 uomini; età media ± DS: 47,9 ± 9,0 anni) che riferivano problemi di salute da loro attribuiti a vessazioni subite in ambito lavorativo o ad altre forme di stress occupazionale. Di questi, 9 (4,5%) erano già stati valutati negli anni precedenti (tre di loro più volte), con la precedente versione del protocollo. Nessuno dei nove pazienti di questo sottogruppo aveva nel frattempo cambiato lavoro; in tutti le diagnosi a suo tempo formulate sono state confermate, con riscontro di peggioramento clinico: due pazienti (un uomo di 48 anni e una donna di 53 anni) erano affetti da disturbo paranoide di personalità con notevoli difficoltà d'adattamento in ambito lavorativo, gli altri sette (4 uomini e 3 donne; età: 48-62 anni) presentavano disturbo ansioso-depressivo (in un caso associato ad abuso alcolico) correlato a stress occupazionale.

Le nuove diagnosi formulate nei 189 pazienti valutati unicamente con il MaSD-2 nel triennio oggetto d'indagine (2017-19) sono illustrate in Figura 1. Tre soggetti (1,6 %) non erano affetti da patologia psichiatrica secondo i criteri del DSM-5, 12 (6,3%) presentavano disturbi psichiatrici non correlati al lavoro (Tabella I), 160 (84,7%) disturbo ansioso e/o depressivo correlato al lavoro (Tabella II). In 12 casi (6,3%) si è posta diagnosi di disturbo dell'adattamento (DA) e in 2 (1,1%) di DA in preesistente disturbo post-traumatico da stress (DPTS), correlabili a mobbing o altre forme di stress occupazionale, per un totale di 14 segnalazioni di malattia professionale alle Autorità competenti (Tabella III).

Discussione

Con l'implementazione del MaSD-2, l'iter diagnostico per la valutazione della patologia da mobbing e stress lavorativo è rimasto invariato (benché arricchito dall'esperienza) nella sua parte clinico-anamnestica (visite psichiatrica e di medicina del lavoro, colloquio psicologico), mentre è stato snellito nella componente riguardante le due interviste strutturate (SCID e MMPI) e arricchito di tre test (S-NAQ, CBA-2.0 e MASI-R) finalizzati a evidenziare eventuali situazioni stressanti e vessatorie in ambito lavorativo. Le psicodiagnosi sono formulate in base alla criteriologia del più recente aggiornamento del Manuale diagnostico e statistico dei disturbi mentali (DSM-5) (9). Con tali modifiche il protocollo non solo è diventato più agile e rapido, ma anche più sensibile e specifico. In altre parole, esso rende più agevole la diagnosi dei casi di psicopatologia da lavoro, differenziandoli dai disturbi psichiatrici di altra natura.

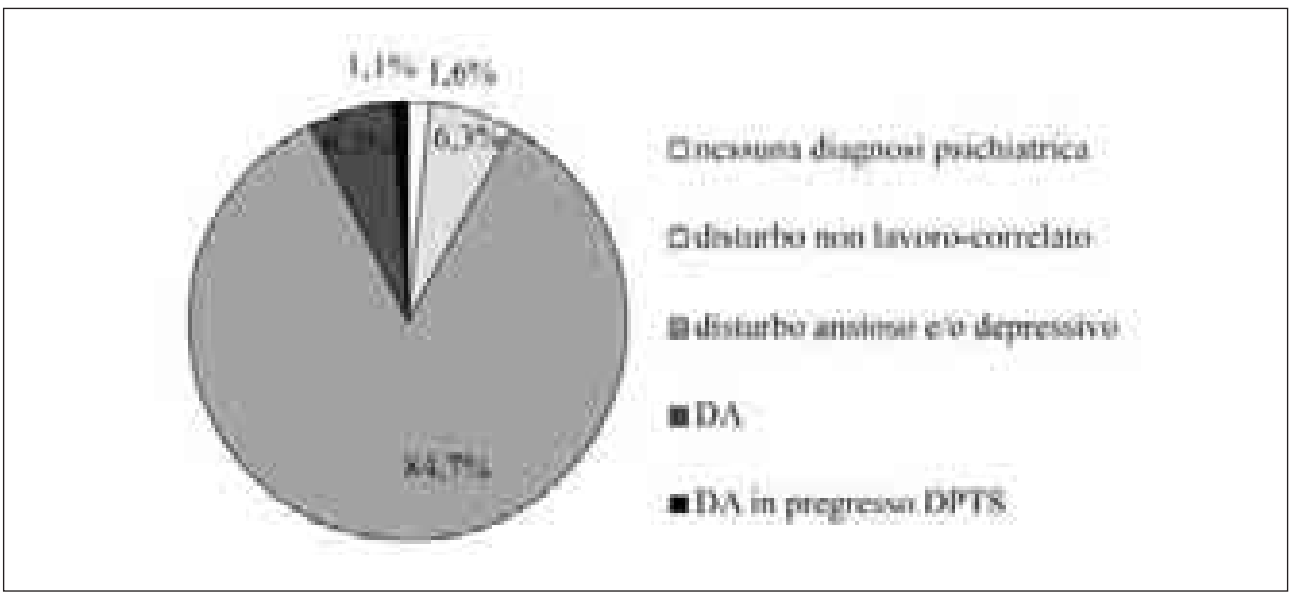

Figura 1. ***Distribuzione percentuale delle conclusioni diagnostiche nei pazienti valutati con il MaSD-2 nel triennio 2017-19 (n = 189); DA: disturbo dell'adattamento; DPTS: disturbo post-traumatico da stress***

Tabella I. ***Disturbi psichiatrici non correlati al lavoro***

N.	Sesso	Età (anni)	Mansione	Diagnosi
1	M	49	Impiegato	Disturbo delirante cronico
2	F	35	Centralinista	Disturbo d'ansia generalizzato
3	M	35	Operaio	Disturbo di personalità NAS
4	M	57	Cuoco	Disturbo di personalità paranoide
5	F	42	Impiegata	Disturbo depressivo ricorrente
6	M	57	Operaio	Disturbo d'ansia generalizzato
7	M	51	Impiegato	Disturbo depressivo reattivo
8	M	42	Addetto call center	Disturbo di personalità NAS
9	M	52	Operaio	Disturbo dell'umore
10	F	48	Fisioterapista	Disturbo di personalità paranoide
11	F	23	Barista	Disturbo di personalità NAS
12	M	28	Addetto vendite	Disturbo ansioso-depressivo

NAS: non altrimenti specificato

Tabella II. ***Caratteristiche dei pazienti con disturbo ansioso e/o depressivo lavoro-correlato (n = 160)***

Caratteristica	% (n) o media (± DS)
Età (anni)	47,8 (± 8,9)
Sesso	
Maschio	36,25 (58)
Femmina	63,75 (102)
Scolarità	
Media inferiore	23,1 (37)
Media superiore	48,7 (78)
Laurea	26,9 (43)
Dottorato di ricerca	1,3 (2)
Categoria professionale	
Operaio	10,6 (17)
Impiegato	38,8 (62)
Dirigente	2,5 (4)
Operatore sanitario	13,1 (21)
Operatore commerciale	13,1 (21)
Altro	21,9 (35)
Settore lavorativo	
Pubblico	25,0 (40)
Privato	75,0 (120)

La casistica esaminata con il MaSD-2 nel triennio 2017-19 include nove pazienti che erano stati già valutati (alcuni in più di un'occasione) negli anni precedenti con la versione originaria del protocollo (due casi di disturbo paranoide di personalità con difficoltà d'adattamento al lavoro, sette di disturbo ansioso-depressivo lavoro-correlato). Nessuno aveva cambiato lavoro o mansione; in tutti il quadro clinico era peggiorato rispetto ai precedenti controlli. Questa osservazione non è sorprendente, in quanto un precedente studio di follow-up sulla nostra casistica aveva dimostrato che lo stress occupazionale può avere conseguenze negative a lungo termine sullo stato di salute. Inoltre, i soggetti che non cambiano lavoro (e che quindi permangono nell'ambiente patogeno) presentano minor soddisfazione lavorativa e maggiore disfunzione sociale (7).

L'analisi del gruppo di pazienti (n = 189) che sono stati valutati per la prima volta con il MaSD-2 ha evidenziato analogie e differenze rispetto alla nostra precedente casistica (13, 19), di seguito elencate e discusse.

Tutti i soggetti del presente studio hanno completato l'iter diagnostico, mentre in passato si osservava un modesto drop-out (1-3%). Questo dato potrebbe essere casuale o, più verosimilmente, essere la conseguenza di una maggiore motivazione dei pazienti che si sono rivolti a noi negli ultimi anni, derivante da una migliore informazione su tempistica e finalità del protocollo.

La casistica recente presenta una percentuale assai elevata (92,1%) di disordini psichiatrici (disturbo ansioso-depressivo, disturbo dell'adattamento, disturbo post-traumatico da stress) correlabili a stress occupazionale, notevolmente superiore a quanto da noi in precedenza osservato (30-50%). Di conseguenza, molto più bassa risulta la quota di pazienti con disordini psichiatrici non correlati al lavoro o ai quali non è stata formulata alcuna diagnosi in base ai criteri del DSM. Questo può dipendere dalle migliori sensibilità e specificità del nuovo protocollo diagnostico ma anche, probabilmente, da una migliore selezione dei pazienti che ci vengono inviati. In altre parole, riteniamo che, nel nostro bacino d'utenza (Provincia di Pavia e territori limitrofi), medici di base, avvocati, patronati (ma anche i pazienti stessi) abbiano compreso nel corso degli anni il rigore e l'obiettività della nostra metodologia, e pertanto evitino d'inviarci lavoratori per i quali una diagnosi di psicopatologia da stress occupazionale appare già in partenza poco probabile.

Come in passato, le donne continuano a rappresentare la maggioranza (60-65%) dei lavoratori con disturbi da

Tabella III. ***Segnalazioni di malattie professionale alle Autorità competenti***

N.	Sesso	Età (anni)	Scolarità	Mansione (settore)	Fattori stressanti occupazionali	Diagnosi
1	F	51	Media superiore	Direttrice ufficio postale (pubblico)	Rapine a mano armata, demansionmento	DA in pregresso DPTS
2	M	32	Media superiore	Operaio metalmeccanico (privato)	Demansionamento, mobbing	DA cronico
3	F	38	Media superiore	Commessa (privato)	Mobbing	DA con umore depresso
4	F	40	Media superiore	Responsabile vendite (privato)	Aggressione fisica, mobbing	DA in pregresso DPTS
5	F	49	Media superiore	Addetta vendite (privato)	Mobbing	DA cronico
6	F	39	Media superiore	Smistamento merci (privato)	Mobbing	DA con umore depresso
7	M	49	Media inferiore	Carabiniere (pubblico)	Demansionamento, mobbing	DA cronico
8	M	47	Media inferiore	Autista, carico merci (privato)	Costrittività organizzative, licenziamento	DA cronico
9	F	51	Laurea (Economia)	Impiegata (privato)	Sovraccarico lavorativo, conflittualità	DA con umore depresso
10	F	57	Media superiore	Impiegata (privato)	Costrittività organizzative, demansionamento	DA con umore depresso
11	F	44	Laurea (Beni culturali)	Insegnante scuola media (pubblico)	Demansionamento, mobbing	DA con umore depresso
12	F	47	Media superiore	Impiegata (pubblico)	Mobbing	DA con umore depresso
13	M	54	Media inferiore	Operatore ecologico (pubblico)	Mobbing	DA con umore depresso
14	M	66	Laurea (Ingegneria)	Dirigente commerciale (privato)	Conflittualità, licenziamento	DA con umore depresso

DA: disturbo dell'adattamento; DPTS: disturbo post-traumatico da stress

stress lavoro-correlato, in accordo con quanto riportato in analoghi studi condotti in Italia (14, 16, 36) e altrove (37-39). Ad essere più colpiti sono i settori educativo, della sanità e dei servizi sociali, dove generalmente è maggiore la rappresentanza femminile. Tuttavia, evidenti e analoghe differenze di genere sono state riscontrate anche in settori a predominanza maschile (36-39).

In particolare, la letteratura scientifica indica che il genere femminile è più frequentemente vittima di mobbing, fenomeno per il quale sono state proposte varie ipotesi esplicative. Secondo alcuni stereotipi culturali, le donne avrebbero un atteggiamento più passivo e quindi più facilmente attaccabile. Inoltre, poiché meno frequentemente ricoprono incarichi dirigenziali, esse sarebbero a maggior rischio in quanto il mobbing è più frequentemente esercitato dai superiori verso i subalterni (5, 39). Nella nostra esperienza, le vessazioni nei confronti di una lavoratrice spesso iniziano quando ella è appena rientrata da un periodo di malattia o di maternità, soprattutto se necessita di allontanarsi con una certa frequenza per provvedere alle cure familiari (13, 19).

Oltre alle differenze di genere, il presente studio conferma che la psicopatologia da stress interessa generalmente lavoratori intorno ai 40-50 anni (quindi nel pieno della loro carriera), con grado d'istruzione elevato, impiegati nel terziario da parte di aziende private, dove maggiore è la competitività e minori le tutele contrattuali e previdenziali.

Un ulteriore elemento di novità è la significativa presenza (>12%) di operatori sanitari, quasi assenti nella nostra precedente casistica. Riteniamo che questo derivi dalla maggiore consapevolezza di questa categoria nei confronti del rischio da stress occupazionale (con maggior tendenza a chiedere assistenza medica e psicologica) (40) e – ancora una volta – dall'aumentata sensibilità del protocollo diagnostico (che include il MASI-R, strumento molto utile per evidenziare il disagio lavorativo in ambito ospedaliero) (33, 34). È probabile che i casi di disturbi da stress nel personale sanitario siano destinati ad aumentare a causa dell'attuale pandemia di Covid-19 (41).

Rimangono rare le diagnosi di DA e DPTS (complessivamente 7,4% nella presente casistica), ossia delle due entità nosologiche per le quali è obbligatoria la denuncia, confermando la necessità di un rigoroso e prudente percorso interdisciplinare, volto a selezionare i casi per i quali avviare procedure medico-legali (42, 43).

Tra le segnalazioni alle Autorità competenti effettuate nel triennio oggetto del presente studio (2017-19), rientrano due lavoratrici alle quali è stata posta una doppia diagnosi (Tabella III, pazienti 1 e 4). Questi due casi, già oggetto di comunicazione preliminare all'81° Congresso Nazionale della Società Italiana di Medicina del Lavoro (44), sono alquanto insoliti, poiché le vittime di eventi stressanti sono di solito diagnosticate come affette o da PTSD o da AD. D'altro canto, la nostra osservazione non è sorprendente per due motivi: (i) i lavoratori che soffrono di PTSD o altri disturbi correlati allo stress si riadattano con difficoltà al precedente lavoro (7); (ii) in molti casi, esiste comorbilità tra PTSD e altri disturbi (come depressione, ansia e abuso di sostanze). Ad esempio, in uno studio su reduci di guerra, quasi l'80% dei casi di PTSD cronici soddisfaceva i criteri per almeno un disturbo di personalità (45). Le nostre conclusioni diagnostiche si sono basate su un'analisi dell'aspetto cronologico dei sintomi: entrambe le pazienti hanno manifestato prima il PTSD (dopo essere state vittime di eventi criminosi), quindi hanno beneficiato di un periodo di congedo per malattia, hanno iniziato il trattamento con miglioramento parziale dei disturbi, sono tornate allo stesso lavoro incontrando notevoli difficoltà e solo successivamente hanno sviluppato il disturbo dell'adattamento.

Nel complesso la nostra esperienza clinica, ormai ventennale, indica che i disturbi psichici di origine professionale sono in costante aumento, in accordo con analoghe, recenti osservazioni (36, 43, 46), richiamando la necessità di adeguate misure preventive. In quest'ambito, il medico competente può svolgere un ruolo centrale, nella collaborazione con il datore di lavoro per la valutazione del rischio e nell'attuazione di eventuali interventi migliorativi, oltre che nella sorveglianza sanitaria e nella formazione-informazione dei lavoratori (4, 23).

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MEDICINA DEL LAVORO

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Protecting hospitals from SARS-CoV-2 infection: A review-based comprehensive strategy for COVID-19 prevention and control

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ABSTRACT. SARS-CoV-2-related infection can determine hospital-acquired infections among patients and healthcare workers. Aim of this paper was to review the literature for developing a strategy for protecting healthcare workers, patients, and visitors by COVID-19 hospital infection. A critical and rapid revision of the literature and international standards and Regulations on this topic allowed us to propose an evidence-based strategy in the framework of the workplace risk assessment for preventing nosocomial COVID-19 outbreaks. The virus' high transmissibility, the high prevalence of asymptomatic carriers and false-negative Covid-19 rates on naso- and oropharingeal swabs, put hospitals at high-risk of COVID-19 outbreaks. A comprehensive strategy based on standard precautions, administrative, environmental, and engineering controls, a screening protocol for patients on their admission to hospital, and a testing-based strategy for HCWs within health surveillance programs may prevent the onset of hospital outbreaks, which are a threat to community, patients and HCWs, compromising the sustainability of healthcare facilities.

Key words: *hospital infection, healthcare associated infection, occupational injury, SARS-CoV-2 prevention, COVID 19 pandemic.*

RIASSUNTO. SARS-CoV-2 può determinare infezioni acquisite in ospedale tra pazienti e operatori sanitari. Lo scopo di questo studio è rivedere la letteratura per lo sviluppo di una strategia per la protezione di operatori sanitari, pazienti e visitatori dall'infezione ospedaliera da COVID-19. Una revisione critica e rapida della letteratura e degli standard e regolamenti internazionali su questo argomento, ci ha permesso di proporre una strategia basata sull'evidenza nel quadro della valutazione del rischio sul posto di lavoro per prevenire le epidemie nosocomiali da COVID-19. L'elevata trasmissibilità del virus, l'elevata prevalenza di portatori asintomatici e di tamponi naso e orofaringei falsi negativi, mettono gli ospedali ad alto rischio per lo sviluppo di focolai da COVID-19. Una strategia globale, basata su precauzioni standard, controlli amministrativi, ambientali e tecnici, su un protocollo di screening per i pazienti al momento del ricovero in ospedale, insieme ad una strategia operativa basata sui test di screening per gli operatori sanitari all'interno dei programmi di sorveglianza sanitaria, possono prevenire l'insorgenza di epidemie ospedaliere che rappresentano una minaccia per la comunità, per i pazienti e per gli operatori sanitari, compromettendo la sostenibilità delle stesse strutture sanitarie.

Parole chiave: infezione ospedaliera, infezione associata all'assistenza sanitaria, infortunio sul lavoro, prevenzione SARS-CoV-2, pandemia COVID 19.

Introduction

Since first being reported in December 2019, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has rapidly spread worldwide. Thus, as of December, 30, 2020, 80,316,555 cases of COVID-19 were globally reported, including 1,770,695 deaths (1). Current scientific consensus suggests that SARS-CoV-2 is transmitted primarily from direct contact via the mouth, nose, or eyes with infected person through respiratory droplets (> 5 μm in diameter). However, transmission may also occur indirectly via fomite contaminated by respiratory secretions or droplets (2) and via droplets less than 5 μm in diameter ("droplet nuclei" or "microdroplets"), the so-called "airborne transmission" (3). These modality of viral transmission places health workers (HWs) at a high risk of infection (4), citing them as a possible source of nosocomial transmission clusters (5). Early available evidence suggested that HCWs are being increasingly infected with the novel infection ranging from 15% to 18% and in some cases up to 20% of the infected population (6). HCWs are more susceptible to COVID-19 due to several risk factors like long duty hours, lack or inadequate use of Personal Protective Equipments (PPEs), uncertain diagnostic criteria, unavailability of diagnostic criteria, stressful and high-risk working environments with concentration of infected patients and high viral loads, lack of measures to prevent the spread in hospitals (6-12).

All these risk factors coupled with the role of asymptomatic or presymptomatic who can act as potential "superspreaders" may contribute to the onset of COVID-19 hospital outbreaks (13, 14). COVID-19 infection is an occupational injury for HCWs (15). At the same time, HCWs can be source of COVID-19 hospital-acquired infections (16), which are nosocomially-acquired infections that are typically not present or might be incubating at the time of admission (17). Healthcare infected can be source of COVID-19 nosocomial outbreaks spreading to the entire community (5). The implementation of effective containment measures is, therefore, particularly important in hos-

pitals and homecare facilities, where the risk of contagion is higher and the magnitude of consequences is amplified by the presence of "frailty" among patients and home care clients, who are often elderly and immune-depressed patients with co-morbidities (18-20). Furthermore, depletion of healthcare workforce may affect the quality of care delivered by overwhelmed healthcare systems, especially for diseases other than COVID-19 (21-23). Hospital outbreaks can be crucial in the sustainment of the viral community transmission. For all these reasons, hospital administrators and managers have to implement effective Infection Preventive Control (IPC) measures. Aim of this paper was to develop a review-based strategy for protecting hospitals from COVID-19 infection outbreaks.

Methods

A literature review focusing on the main preventive and protective measures in healthcare facilities against COVID-19 and including administrative engineering, environmental, and individual measures was carried out. SARS-CoV-2 infection characteristics and some challenging diagnostic aspects of COVID-19 infection, were also analyzed. The literature review was the starting point for developing a screening pathway for patients on their hospital admission, and a targeted workplace health surveillance programme for screening hospital workers. Due to the current health emergency, a rapid review design, which is a "type of knowledge in which components of the systematic reviews process are simplified or omitted to produce information in a short period of time" (24), by limiting inclusion by date or language and reporting results narratively, was used (25). Rapid reviews have been described as a "streamlined alternative to standard systematic reviews" and a key use of this type of review is to provide summary evidence in an environment where health service delivery decisions need to be made quickly and not within the time frames of traditional reviews (25). They also provide a format that makes evidence accessible for decision makers and are a valuable way of supporting evidenced-based decision making (26). Relevant terms relating to the following themes: "healthcare outbreaks"; "health surveillance"; "preventive measures" were combined. Searches were initially limited to May 25, 2020 and were updated to December 31, 2020 to ensure that current findings are included in the analysis and that results are relevant to current services. A combination of free-text and medical subject headings (MeSH) search terms, as well as appropriate subheadings, was used. Key words such as "Infection control", "Hospital", "diagnosis", "Hospital transmission", "SARS-CoV-2", "2019-nCoV", and "COVID-19" were used in several combinations. Two authors (FC and AS) independently conducted targeted database searches using the following databases: Medline, PMC, and Google Scholar. COVID-19 resources center by Lancet, New England Journal of Medicine, JAMA, Nature, Cell, BMJ, Science, the most important publishers (Elsevier, Oxford, Wiley), and non-peer reviewed papers from medRxiv and Google Scholar were consulted, as well as Italian and international guidelines, including those published by the US-Centers for Disease Control and Prevention (CDC), the European Centre for Disease Control and Prevention (ECDC) and the WHO. Only papers written in english and Italian languages were considered. The articles included were analyzed qualitatively.

Results and Discussion

Proposal of a strategy for the prevention of COVID-19 hospital outbreak/ COVID-19 Hospital-Acquired Infection

The risk of COVID-19 hospital-acquired infections and hospital outbreaks stems from several SARS-CoV-2 characteristics: the high transmissibility of the SARS-CoV-2; the high and unknown prevalence of asymptomatic carriers of the virus (27); the plurality of modalities of transmission (i.e., by fomites, droplet contacts and airborne transmission) (2, 3), and the high probability that patients, hospital visitors and healthcare staff who are infected can transmit the infection when asymptomatic, paucisymptomatic or presymptomatic (before 48 hours the onset of symptoms) (28). The fact that neither epidemiological nor clinical criteria permit to identify and isolate patients, visitors or carriers of infection, is the major determinant of COVID-19 infection in terms of either hospital-acquired infection and hospital-associated outbreaks. We developed a tailored strategy for preventing them (Figures 1a, 1b, and 2), which is based on early recognition and source control of COVID-19 in HCWs, hospital workers, visitors and patients, and the application of standard precautions for all patients, regardless of suspected or known infection. The implementation of additional precautions for COVID-19 infected patients, as well as administrative, environmental and engineering control measures were also included, in the framework of the workplace risk assessment (WRA), which is the "core" process of health and safety practices at workplace, aimed to identify, control and eliminate all the hazards for workers and third parties (29).

Administrative, environmental, and engineering controls

Administrative control measures are as the following: 1) routinely refreshing training to all the hospital staff on the IPC measures; 2) primary screening of workers, visitors and patients at all the entrances of the hospital (temperature and symptom screening; 3) different pathway for patients with suspected COVID-19 infection; 4) person-to-person distance of at least 1,5 mt (e.g., waiting area); 5) universal masking of visitors; 6) implementation of online consultation system; 7) primary screening and testing and temporary isolation for patients waiting for confirmation ("isolation room" within both emergency rooms and wards), and when single rooms are not available, people suspected of having COVID-19 should be cohorted together; 8) different treatment sites for COVID-19 patients on the basis of the illness severity (29, 30).

The main environmental preventive measure is ensuring environmental cleaning and disinfection procedures with commonly used hospital-level disinfectants (e.g., sodium hypochlorite).

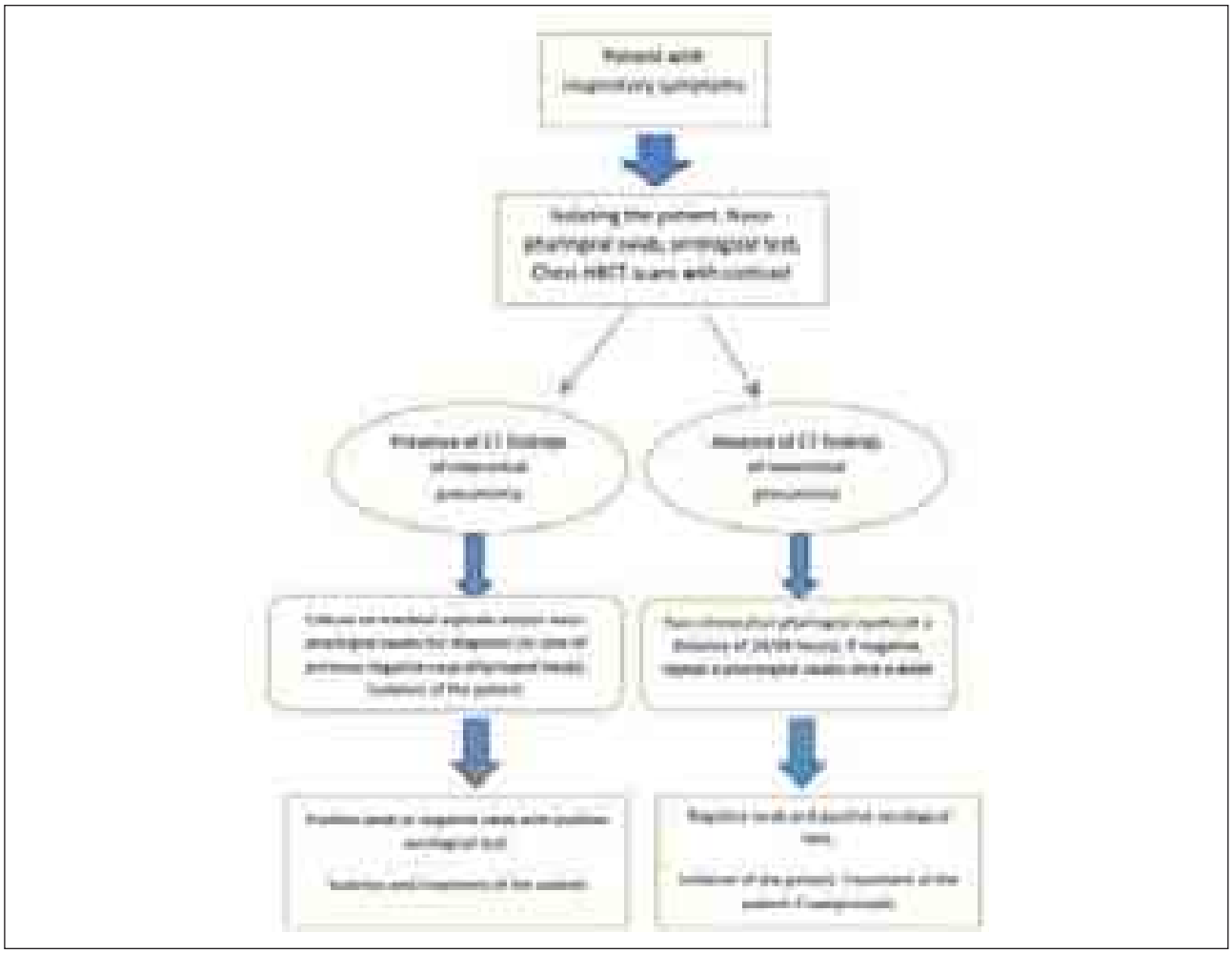

Figure 1a. *Procedure for monitoring patients with COVID-19 suspected symptoms admitted to hospital*

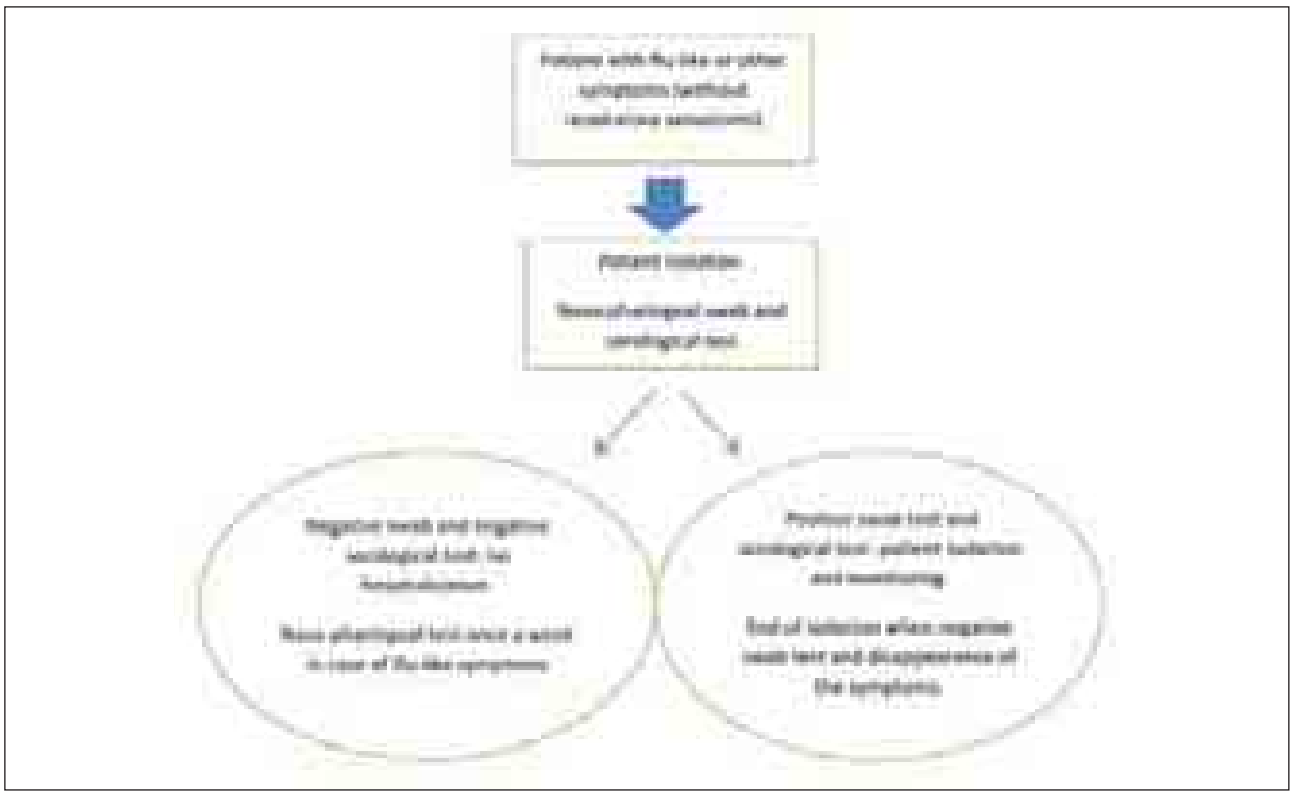

Figure 1b. *Procedure for monitoring patients without respiratory symptoms admitted to hospital*

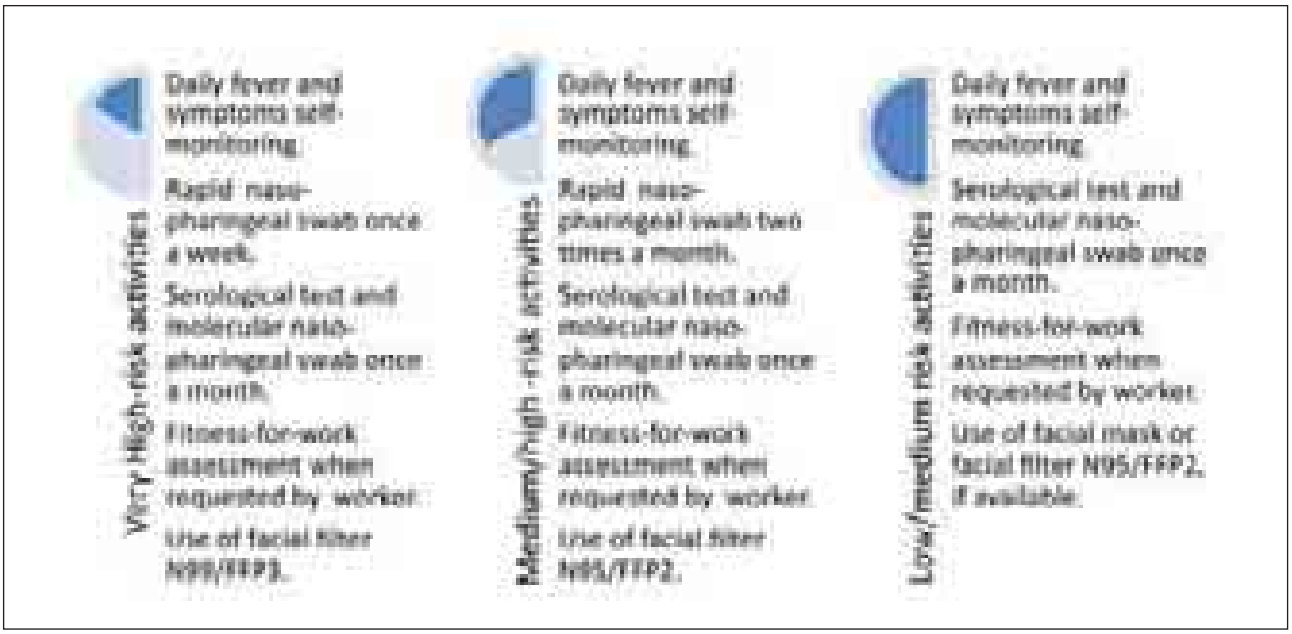

Figure 2. ***Health surveillance protocol for hospital healthcare workers***

With regard to engineering control measures, natural ventilation can be used in airborne precaution rooms, whereas a mechanically ventilated room with special features in air handling and airflow direction should be used for infection isolation rooms (29, 31). Heat Ventilation Air Conditioning systems need that air from the room can be exhausted directly to the outdoors, where the droplet nuclei will be diluted in the outdoor air, or alternatively passed through a special HEPA filter that removes most (99.97%) of the droplet nuclei before it is returned to the general circulation (3, 29), especially if aerosol-generating procedures are performed (29).

Current challenges for COVID-19 identification and diagnosis in HCWs and patients

Currently, there are two main tests available for COVID-19: direct tests (i.e., molecular tests) that are designed for diagnosing a current infection, and indirect tests (i.e., serological tests) that are designed to ascertain seroconversion upon a previous (IgG) or an early (IgM) infection. A combination of these tests may inform crucial decisions by healthcare providers and policy makers (32). The COVID real-time reverse transcriptase-polymerase chain reaction (RT-PCR) test is considered to be the gold standard test for the qualitative and quantitative detection of viral nucleic acids. Several point-of-care tests (POCTs), which are rapid antigen tests were developed for rapid diagnosis of infected patients. However, these tests tend to have lower sensitivity than RT-PCR. Therefore, even if they may be useful during an ongoing outbreak, when timely access to sensitive molecular testing is unavailable, a negative result should be interpreted by a healthcare professional with caution and based on clinical judgement (33). In the event of suspected symptoms, the molecular swabs should be immediately performed to confirm diagnosis, isolate the positive subject and trace his/her contacts (34, 35). RT-PCR is the frontline diagnostic test for COVID-19 that is capable of analyzing thousands of specimens in a single day and shows a testing sensitivity of 95% (36). It can be carried out on different types of samples (i.e., nasopharyngeal swab, oropharyngeal swab, bronchoalveolar lavage, tracheal aspirates, and saliva). At present the US-CDC recommend collecting and testing a nasopharyngeal specimen as the preferred choice for swab-based SARS-CoV-2 testing. For individuals having invasive procedures, lower respiratory tract specimens are recommended, if available (37). The RT-PCR technique shows, however, some analytical problems, such as inadequate procedures for collection, handling, transport and storage of the swabs, manual errors, testing outside the diagnostic window, active viral recombination, use of inadequately validated assays, that contribute to jeopardize the diagnostic accuracy (38). In literature, authors have reported several cases of COVID-19 patients with false negative swabs (39-49). Since the risk for recurrent infection with SARS-CoV-2 is not known for COVID-19, detection of one or two antibodies (IgM and/or IgG) does not necessarily guarantee immunity against reinfection. Furthermore, negative results do not rule out SARS-CoV-2 infection, particularly in those who have been in contact with the virus and positive results may be due to past or present infection with SARS-CoV (50). The Italian National Institute of Health recommends using CLIA and ELISA serological tests, with a specificity of at least 95% and sensitivity of at least 90% (51), only for epidemiological surveys on communities such as occupational cohorts, but not for clinical diagnosis as a substitute of swab tests (52, 53). Due to the shortage of kits and false negative rate of RT-PCR, the Hubei Province, China temporarily used CT scans as a clinical diagnosis for COVID-19 (54). CT systems are expensive, require technical expertise, and cannot specifically diagnose COVID-19 (55), yet they can be highly useful for early diagnosis and follow-up (42, 56-58), having a higher sensitivity in

patients with positive RT-PCR (59), and lower in patients with only non-respiratory symptoms (60). Conventional chest X-ray sensitivity is at around 59% (61). Ultrasounds show an estimated sensitivity of 75%, with a low specificity and high variability depending on factors such as disease severity, patient weight and operator skills. Therefore, they could be useful as a screening tool in combination with clinical finings and molecular testing for early diagnosis, for monitoring the progression of the disease (62), and distinguishing COVID-19 by community-acquired pneumonia (CAP) (63).

Testing strategies on HCWs and patients

To identify and isolate asymptomatic patients admitted to hospital, it is insufficient a single oro-nasopharyngeal swab tests before the admission. The critical point concerns the quality of the samples. In case of suspected infection, operators should collect swabs by multiple sites, taking into consideration both the symptoms and the stage of the clinical course. In presence of radiological signs (bilateral interstitial pneumonia) of COVID-19, swabs should be taken by lower airways. For diagnosis, chest High Resolution Computed tomography (HR-CT) manifestations can supplement parts of limitations of real-time reverse transcription polymerase chain reaction (RT-PCR) assay. Serological tests can contribute to diagnosis, where they are complemented with naso-pharingeal swab tests (52, 53). In case of patient with respiratory symptoms (breathing difficulty, cough, chest pain), all the containment measures should be activated in any case.

One of the most known strategies to control the spread of COVID-19 infection among hospital staff is the 3T (testing, tracing, and treating) strategy (11, 62). In Indonesia polymerase chain reaction (PCR) swabs tests, implementation of contact tracing and isolation of infected operators were effective for controlling the spread of COVID-19 and reducing the risk of spreading infection (11). In Korea, the robust control of a COVID-19 healthcare-associated outbreak minimized the transmission of SARS-CoV-2 within hospitals and local communities. However, there was also much debate over the appropriate period of hospital shutdown and testing of all hospital staff and patients (62). In one of the largest international survey studies in the field of surgery, significant rates of centers had experienced in-hospital COVID-19 infection (31.5%) worldwide, confirming a wide prevalence of the initial symptom-based preoperative testing policies, which may have missed the asymptomatic case (63). International and local surgical guidelines recommend preoperative testing when available and practical, considering that SARS-Cov-2 make asymptomatic patients more likely to transmit the disease than in the previous epidemics (63). A study from China reported a higher prevalence of asymptomatic COVID-19 infection in hospitalized patients (5.8%) compared to the community (1.2%) (64), and asymptomatic hospitalized patients were frequently reported as a source of in-hospital outbreaks (65).

Occupational health surveillance of HCWs and hospital workers can be decisive for protecting hospital from COVID-19 infection (66). HCWs may be "dangerous" for patients and family members. Trough mandatory health surveillance, "vulnerable" workers (i.e., those affected by cardiovascular diseases, chronic obstructive pulmonary diseases, diabetes mellitus, conditions of immunosuppression, or other conditions associated with higher risk of COVID-19 related complications and mortality) can be monitored. There are currently no widely available reliable antibody testing to demonstrate both current and previous COVID-19 infection, thus their usage could raise technical and ethical concerns (67). On the contrary, all HCWs, including those asymptomatic, should be routinely tested with Reverse Transcription Polymerase Chain Reaction (RT-PCR) testing on nasopharingeal swabs for early diagnosis of SARS-CoV-2 (66). Viral test are the best available tools to diagnose current infection with SARS-CoV-2 and point-of-care tests, meaning results may be available at the testing site in less than an hour, could be particularly useful.

Standard precautions and individual IPC measures for preventing COVID-19 hospital infections

Standard precautions include hand and respiratory hygiene, appropriate PPEs, injection safety practices, safe waste management, proper linens management, environmental cleaning, and sterilization of patient care equipment. All individuals, including family members, visitors and health-care workers, should apply contact and droplet precautions (67, 68). WHO has developed the WHO COVID-19 risk assessment tool (69). HCWs are classified as "high" or "low" risk to COVID-19 infection, if they follow or not, respectively the IPC measures while performing medical activities and aerosol-generating procedures on COVID-19 patient in health care facilities. IPC measures on COVID-19 patients include wearing of single-use gloves, medical masks, face shield or goggles/protective glasses, disposable gown, removing and replacing PPEs according to protocol, performing hand hygiene (before and after touching a COVID-19 patient, before and after any clean or aseptic procedure, after exposure to body fluids, after touching patient surroundings) and decontaminating high touch surfaces at least 3 times daily. The IPC measures during aerosol-generating procedures include wearing of single-use gloves, N95 mask (or equivalent operator), face shield or goggles/protective glasses, disposable gown, waterproof apron, removing and replacing PPE according to protocol, performing hand hygiene (before and after touching a COVID-19 patient, before and after any clean or aseptic procedure, after exposure to body fluids, after touching patient surroundings), decontaminating high touch surfaces at least 3 times daily, whether the healthcare worker had any type of accident with body fluid/respiratory secretions of a COVID-19 patient (67-69).

According to the WHO, strategies to protect HCWs from hospital-acquired COVID-19 infection should include training of HCWs to recognize respiratory diseases, an increased access to PPEs, support for HCWs to reduce their high workload, a strong hospital surveillance system filling the existing gaps of the healthcare system to protect HCWs and their patients.

As suggested by Ashinyo et al (70), HCWs should adhere to WHO and national IPC protocols through constant

training on IPC protocols coupled with a regular supply of appropriate PPEs and supportive supervision of HCWs exposed to the COVID-19 virus.

PPEs in healthcare facilities

The PPEs needed to protect HCWs are masks (face masks and shields), respirators, gloves, body covers and googles. A systematic review of observational studies on Severe acute respiratory syndrome (SARS), Middle East respiratory syndrome (MERS) and COVID-19 found that the use of N95 or similar respirators might be associated with greater reduction in risk than medical masks. However, very few studies included in the review evaluated the transmission risk of COVID-19. Despite the WHO's call for increased production of PPEs (71), and WHO, CDC, and FDA have suggested their rational use (72-74), there are still shortages of PPEs (4, 75, 76) for healthcare personnel.

There are two types of mask for medical use in healthcare facilities: 1) medical masks that are defined as surgical or procedure masks; and 2) Filtering facepiece respirators (FFR), or respirators, offer a balance of filtration and breathability. European FFP2/FFP3 guarantees a filtration of at least 94%/99% solid NaCl particles and oil droplets and corresponds to US N95, filtering at least 95%/99% NaCl particles (77). Policies on wearing a mask for HCWs have been much debated (4, 77, 78). The WHO guidelines recommend that health care workers should wear a medical mask when entering a room where patients with suspected or confirmed COVID-19 are admitted (79). This WHO's document published on 5 June 2020 and updated on 1 December 2020, recommend for HCWs the use of medical mask in the absence of aerosol generating procedures (AGPs), and the use of FFP2/FFP3 only when AGPs are performed, or in other care settings if they are widely available and if costs is not an issue. In areas of known or suspected community or cluster SARS-CoV-2 transmission, universal masking for all persons (staff, patients, visitors, service providers and others) within the health facility (including primary, secondary and tertiary care levels; outpatient care; and long-term care facilities) is advisable. WHO recommends, furthermore, adherence to correct mask management practices (79).

Bellato et al. (63) in their study on surgeons argue that local testing capability and PPEs availability are the best protective measures under the current risk of asymptomatic COVID-19 patients. Saran et al (80) showed technical issues concerning design and materials of PPEs. In their systematic review, Tian et al. (81) showed that community mask use could be beneficial, but higher-level specification of masks and respirators could provide better protection for HCWs (78, 79). WHO (82), CDC (83) and ECDC (84) released strategies to tackle SARS-CoV, MERS-CoV and SARS-CoV-2 infections. They include a risk assessment, which is based on type of activity performed by HCWs (Table I).

Conclusion

Preventing COVID-19 hospital infections has a positive impact on healthcare systems and community. A review-based comprehensive strategy integrating occupational health practice and public health activities, can promote their respective preventive strategies (85-87). The proposed protocol, finally, could be useful for the current COVID-19 pandemic and for future epidemic driven by new and old airborne-transmitted biological hazards.

CRediT authorship contribution statement

Francesco Chirico: Conceptualization, Methodology, Literature search, Writing – original draft, editing, Supervision. Gabriella Nucera: Conceptualization, Writing – review & editing. Angelo Sacco: Literature search, review. Giuseppe Taino: Review & editing. Marcello Imbriani: Review & editing.

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Conflicts of interest

None declared.

Table I. ***Coronavirus infection prevention strategies***

Biological hazard	WHO		CDC		ECDC	
	Low risk profile	*High-risk profile*[1]	*Low risk profile*	*High risk profile*	*Low risk profile*	*High risk profile*
SARS-CoV	FFP2/FFP3 respirator[2]	FFP2/FFP3 respirator	FFP2/FFP3 respirator	FFP2/FFP3 respirator	–	–
MERS-CoV	Surgical mask	FFP2/FFP3 respirator	FFP2/FFP3 respirator	FFP2/FFP3 respirator	Surgical mask/ FFP2/FFP3 respirator	FFP2/FFP3 respirator
SARS-CoV-2	Surgical mask	FFP2/FFP3 respirator	Surgical mask	FFP2/FFP3 respirator	Surgical mask/ FFP2/FFP3 respirator	FFP2/FFP3 respirator

Note: CDC, Centers for Disease Control and Prevention; ECDC, European Centre for Disease Control and Prevention; WHO, World Health Organization. 1: Aerosol-generating procedures; 2: FFP2 / FFP3 respirators; 3: Based on the risk assessment; 4: surgical mask and, if available, FFP2 / FFP3 respirators.

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MEDICINA DEL LAVORO

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Results of the implementation of a virtual control approach to improve the effectiveness and quality of Safety and Health inspections at workplaces

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ABSTRACT. During the last years, a significant technological and organisational evolution is taking place in the industrial activities, thanks to Advanced Manufacturing together with a more and more widespread use of Cloud Big Data Analytics. With special reference to the OS&H (Occupational Safety and Health), these changes involve a new attention, both to the technological and employee's level. The paper discusses the characteristics, and the possible original use of a new methodology, based on virtual reality and digital checklist. This methodology can be used both to easily carry out surveillance activities and checks at workplaces, and to create a virtual itinerary of the area under investigation, in which checks and operative instructions can be virtually introduced for workers in charge of particular machinery or operations. The main results obtained thanks to the implementation of the methodology are: a reduction of the remedial actions' duration on non-compliances brought into evidence, and the deriving possible increase in the frequency and efficiency of inspections. Moreover, this approach intrinsically favors the involvement of workers and staff in charge of activities related to Prevention and Protection, supporting a process of continuous improvement and of general spread of the Culture of Safety in the Company.

Key words: *Occupational Health and Safety, Safety inspections, virtual Safety control.*

RIASSUNTO. Risultati dell'implementazione di un approccio di controllo virtuale per migliorare l'efficacia e la qualità delle ispezioni in materia di sicurezza e salute sui luoghi di lavoro. Negli ultimi anni si è assistito in ambito industriale ad una sostanziale evoluzione tecnologica e organizzativa, resa possibile dalle Advanced Manufacturing associate ad un impiego sempre più pervasivo di Cloud Big Data Analytics. Nell'ambito della Sicurezza e Salute del lavoro questi cambiamenti rendono essenziale una nuova attenzione, sia dal punto di vista tecnologico sia per quanto concerne il personale. Pertanto, in questo articolo, sono discusse le caratteristiche e le possibilità di impiego di una applicazione di una nuova metodologia, basata sulla realtà virtuale e su una checklist digitale, utilizzabile per effettuare in modo semplice le attività di sorveglianza e verifica nei luoghi di lavoro, consentendo di creare un percorso virtuale nell'area in esame, nel quale sono inseriti in maniera visuale gli accertamenti da eseguire e le istruzioni operative per addetti a particolari attrezzature od operazioni. I principali risultati ottenuti grazie all'applicazione sul campo della metodologia sono: riduzione del tempo di intervento su una non conformità e conseguente aumento della frequenza dei controlli e della loro efficacia. L'approccio favorisce

1. Introduction

Starting from the beginning of the '80s, the scientific cooperation of experts of Polytechnic and University of Turin focused on the new approach to Safety and Health some years later officially adopted in the Economic and Social EEC Directives (1,2). The main result was a shared and well tested Risk Assessment and Management methodology, a valuable reference to comply effectively with the requirements of the new safety regulations, leaving aside the obsolete prescriptive approach of proven poor efficiency (3).

As summarized in Borchiellini et al., 2018 (4), the implementation of the methodology made it possible to draw up Guidelines internationally and nationally officially approved, initially specific for mining activities (5-7). The Guidelines have been gradually extended to a number of NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) sectors characterized by particular criticalities (e.g. construction (8-10), important public structures (11-12), etc.), and systematically updated in coherence with the research activities of the Occupational Health group (13-14).

In coherence with the original approach, which made possible the development of the methodology, the multidisciplinary research group, which includes the authors and other professionals, currently operating at the headquarters of Occupational Health, Turin University, focused on the following goals:

- Setting, in close cultural synergy, of theoretic applicative research and of methodological in-depth analysis on Occupational Health and Safety. Some recent results are discussed in (15-26);
- Dissemination of the Culture of Safety, that can play a key role in the reduction of risks of workers. Indeed, this is an essential goal that still now needs substantial development, based upon in-depth analysis of its multiple aspects (27-29). Educational processes should be specially tailored for different groups of people identified on the basis of some common characteristics, this also includes the optimizing of the university education at various levels, from degree programs to masters and specific courses for PhDs (30-33), and renowned international Masters (e.g. the ITC ILO Master on

intrinsecamente anche la partecipazione di lavoratori e preposti alle attività legate a prevenzione e protezione, favorendo un processo di miglioramento continuo e di generale incremento nella disseminazione della cultura della sicurezza in azienda.

Parole chiave: Salute e Sicurezza nei luoghi di lavoro, ispezioni di Sicurezza, controllo virtuale della Sicurezza.

Occupational Safety and Health (34)), in addition to the collaborations for research and formation at public and private Institutions and Organizations (35).

This cultural synergy made the research group able to study new Industry 4.0 challenges and risks. Nowadays, the Industry 4.0 development is basically modifying the workplaces, in terms of reorganization of processes and activities (36). The progressive introduction of Enabling Technologies (37) in the productions systems and their management is taking on fundamental importance. Both processes and employees are becoming of systemic relevance, conditioning the possible enhancement in the efficiency of production and support systems in almost all the economic NACE sectors (38). The technological and organizational evolution, possible thanks to Advanced Manufacturing Solutions (39), is associated to a growing use of Cloud Big Data Analytics (40) and makes necessary to reshape the cultural approach of the workforce, supporting its adjustment to the new tasks. In addition, with the transformation in terms of 4.0, today it is possible to manage nets and interconnections of equipment to optimize processes, and to develop mutual process – product information exchanges. However, the more a system becomes articulated and complex, the more chances of deviation can increase. These chances are not simple to identify at the design phase and can result in scenarios for which processes of self-test and self-correction were not implemented. The well-known Swiss cheese model proposed by J.T. Reason (41-42) can be a useful benchmark also in this case. It is then clear how absolute is the necessity of adjustment within a rigorous System Safety approach of all the phases of work-related Hazard Identification, Risk Assessment and Risk Management (given the GAH-EEC recommendation (43)). The rapid improvements of techniques and technologies not always correspond to adequate developments of the Assessment and Management of OS&H risks: the current situation sometimes stays anchored to approaches that are no longer coherent with the needs of an evolving world (44-46), particularly with reference to: performances of completeness, efficiency and promptness (47); coherence to the modern vision of OS&H as a subpart within a quality system (48-49); and ability to make full use of the current technological resources and information management techniques, coherent to the expectations and capabilities of digital generations.

Moreover, the Employer's task is more demanding: the complexity of technologies, the systems three-dimensional extent, the behavior of physical and chemical pollutants in articulated systems make necessary both abilities to exhaustively identify and analyze these criticalities, and to define suitable control measures (50); planning and advanced technological options should be implemented in a scenario of exasperated contraction of the production times, which in terms of OS&H means being able to recognize and quickly prevent critical situations; OS&H management must involve experts in different fields, such as engineering, occupational health, metrology, computer science etc., and it is certainly now more necessary than ever to adopt the approach of cultural synergy recommended since mid-20th century by CECA (see Fiches thématiques sur l'Union européenne - Santé et sécurité au travail, (51)) (Figure 1).

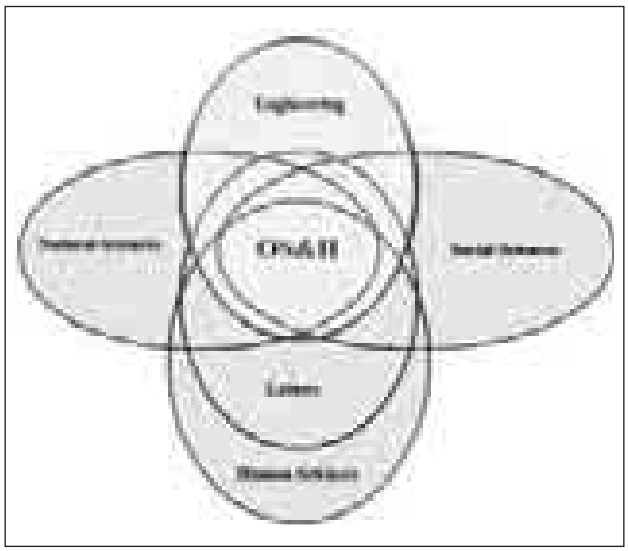

Figure 1. ***Multidisciplinary structure of Safety sciences (C.E.C.A. documentation). Translated from the original in French***

Therefore, an updated commitment to satisfy these needs is necessary and can contribute to the economic efficiency of a company. Such efficiency is achieved only by considering OS&H as *"a factor of a well working system"* (52).

The use of checklists –strictly derived from a preliminary dedicated and rigorous analysis- is often recommended, given their advantages in terms of efficiency and flexibility, coherently with the recommendations in the document of GAH_EEC. The user friendliness of the checklist technique makes possible to commit the infield activities to operators with a basic formation, leaving the decisional interventions to OS&H experts. Moreover, the approach makes also possible to enhance the frequency of review inspections, with both "technic" and psychological advantage, as discussed in Borchiellini et al., 2017. However, given the criticalities mentioned above, the huge amounts of data and information deriving from inspections are today difficult to manage using common paper checklists. In this respect, virtual reality (VR) can be useful to supply information in a more natural and effective way if combined with a digital checklist. VR is a mature technology, that add digital information to reality, already applied to a series of services within the factory. Moreover, VR is already a technological base for the development of digital environments, monitoring/control,

and training (53). VR applications have been reported in literature also for virtual prototyping, web-based virtual machining, assembly, fault diagnosis, and various types of manufacturing operations (54). Thus, the aim of this paper is to illustrate the results of a new methodology, based on VR and digital checklist and coherent to the current technological evolutions and principles of management quality, tested in the field of OS&H management. This new methodology can constitute a modern and time / moneysaving approach, which allows effective autonomous guided assessments, the reduction of the persistence in time of non-conformities and the velocity of implementation of corrective actions.

2. Materials and Methods

2.1. Definition of the requirements

To design a successful methodology, the first step was the identification of the requirements, which was performed by setting up a focus group. The focus group included seven experts, from consulting firms and institutions, requested to talk about the requirements that an improved methodology should have to optimize the general and timely verification of safety conditions in the workplace. This technique refers to that used in the field of Quality to determine customer requirements for products (55).

The requirements identified by the focus group were:

- To reduce the amount of paper documents (by providing a computerized support);
- Small and light enough to carry around easily;
- Easiness of operation, even though small in size;
- Availability and storage of a wide range of implementing possibilities of schemes, pictures and videos, observation, and annotations directly on the ground;
- Possibility to online contact with the expert and rapidly receive indications and suggestions;
- Providing a tool of information and (interactive) formation for the employees;
- Capability to memorize the history of the results of routine checks and improvement interventions;
- Generation of reports of the verification operations and the interventions carried out;
- Flesibility in terms of updates.

2.2. Identification of the technology which fulfils the requirements

The second step was the identification of the technology that could fulfill the general requirements identified. It was chosen a technology already known to the focus group for

the identification of the controls to be performed by the operators during the different work phases and for Lean Manufacturing - 5S, in particular for the “Seiketsu - Systematize or standardize” phase (56). That technology was also used in formation and training (e.g. for training courses on specific risks in production activities and for training on the job through mobile devices) thanks to the possibility of creating courses with the insertion of multimedia content and learning tests.

The technology is composed by:

1. a web platform for the creation and storage of Virtual Tours[1], consisting of a set of multiple flat or panoramic photographs up to 360°, connected and navigable (Back-office) for navigation and interaction of the virtual tours themselves and for report management (Front-end). In particular, in each virtual tour “clickable” points called “hotspots” of various types can be inserted, including:
   - hotspot navigation to check the accessibility of each desired point during the tour;
   - information hotspots where it can be uploaded instructions or procedures in video and audio;
   - “pdf” hotspots to attach documents that can be consulted during the tours;
   - “link” hotspots for entering internet addresses, etc.;
   - interaction hotspot, to make it possible to introduce answers and comments, upload video and audio photos as well as choose answers proposed from the drop-down menu.
2. an app for iOS and Android systems, for browsing and interacting with virtual tours on mobile devices, both online and offline (with download of virtual tours on the device: this is particularly useful both in areas where there is no data or wireless network coverage). It can also generate reports and performs statistical analyzes on the data collected.
   There are two access levels:
   - User level: used by those who perform virtual tours in situ.
   - Super-user level: used by subjects who, in addition to being able to perform virtual tours, are enabled to view the reports and act at a decision level.

   Table I illustrates how the technology can operate.

2.3. On-field implementation

The third step was the implementation of the methodology to the management of Occupational Safety and Health. The platform and app were adapted for equipment maintenance checks, for verification safety devices and equipment, and fire prevention and protection devices, with the possibility of generating replacement reports of the register (as required by the Italian official regulations (57-59)).

Using the platform and app of the technology selected, it was possible to organize a checklist management technique. This technique was implemented in 21 companies (through voluntary participation) divided into the following sectors: one in the publishing sector, one in the rubber processing sector, two in the chemical and pharmaceutical sector, three in the construction sector, four in the food industry sector, six in the metalworking sector and four from the service sector (Figure 2). The technique was

[1] The process of creating a virtual tour is already consolidated in popular applications such as Google Street View.

Table I. ***How to access the platform/app based on user level***

Modality	Activity	Access
Back-office	- Virtual tours' creation and management; - Reporting system's creation and management; - Creation and management of personal settings.	- From PC / MAC (browser); - With authentication.
Front-end PRIVATE	- Archive of reserved virtual tours; - Navigation of reserved virtual tours and report generation; - Report view.	- From PC / MAC (browser) or mobile (browser or APP); - With authentication.
Front-end PUBLIC	Virtual tours freely available in which navigation hotspots, information, video / audio, and pdf can be inserted, but not interaction hotspots.	- From PC / MAC (browser) or mobile (browser or APP); - With no authentication.

set and improved alongside the surveys in the 21 companies, and organized starting from the development of a dedicated radar image on which the observation points (navigation hotspots) were positioned for each area (e.g. workplaces, departments, etc.). Thus, a unique reference for the planned inspection path was available (Figure 3), and it was guaranteed that a 360° panoramic view was associated with each observation point (Figure 4).

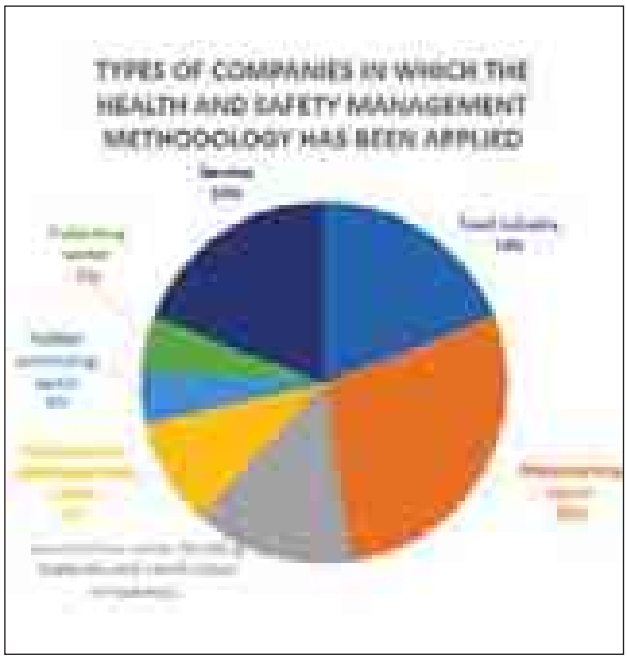

Figure 2. ***Main types of activities in which the health and safety management methodology has been applied***

Figure 3. ***Example of a radar image that allows to move virtually in the premises and areas of the departments***

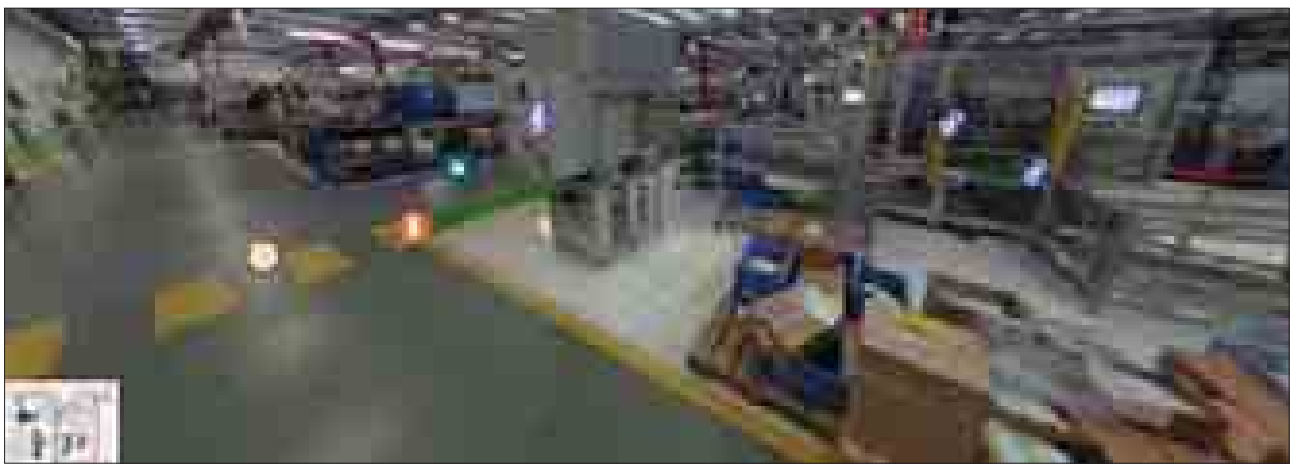

Figure 4. ***Example of a pre-recorded overview on tablet, depicting what is visible during the investigation by the employee with visible interaction hotspots***

The various types of hotspots were operated as follows:

- the information hotspots were used to insert instructions and procedures that needs to be followed, in the form of video and audio supports;
- the "pdf" hotspots have been used to attach reference documentation on instructions or safety procedures that can be consulted during the tours;
- the "link" hotspots have been used for the insertion of internet addresses which give the possibility to open the destination page in a browser window;
- the "interaction" hotspots were used to highlight any "non-conformities" found, by proposing ad-hoc questions during navigation that provide for binary (YES / NO) or textual answers (known fields), or insertion during virtual tours of photographs, audio or video or even answers from preset drop-down menus.

The basic questions - which were implemented during the surveys in the 21 companies - referred to the basic criterion discussed in Borchiellini et al., 2016, summarized in the diagram illustrated in Figure 5.

The controls were divided into macro categories and subcategories (Table II) so that by filtering the results the report analysis phase becomes easier.

Figure 5. ***Approach for the assessment and management of OS&H risks***

Table II. ***Macro categories and examples of subcategories***

Structural characteristics	**General support services (including emergency management)**	**Equipment (plants, machines, work tools, ...)**	**Operations (e.g. organisation including materials and workers)**
Examples doors, walls, windows, floors, mezzanines, step and ladder stairs and other architectural elements; luminous and non-luminous horizontal and vertical signs and parabolic or hemispherical mirrors; asbestos: periodic inspection of asbestos-containing artefacts, encapsulated and confined artefacts[2].	Examples firefighting: surveillance of devices and equipment such as fire extinguishers, hydrants, alarm buttons; evacuation: security doors and opening devices, emergency signs and light signs; intervention devices: such as first aid kits, medication packages, defibrillators and medical rooms; Special PPE (Personal Protective Equipment); Emergency response teams: training on the intervention procedures provided for in the corporate emergency plan.	Examples electrical equipment: switchboards, sockets, cables and connections, extension cables; equipment: safety devices, immaterial barriers, microswitches, fixed and mobile guards, stop buttons, etc.; compressed air distribution systems, gas distribution systems (flammable, oxidizing, inert, medical, etc.) including valves; liquid distribution systems (fuels, lubricants, water, steam, superheated water) including valves and gate valves; walkways, passages, ladders, railings serving production lines and plants; portable electric appliances; centralized and localized suction systems; room lighting, safety and emergency.	Examples working and lifting equipment (check before use and functional checks) transportation (checking the vehicle before use and checking the load) control of processes and work phases, control of the construction site and safety documents inspection audits; business documents; external company documents DUVRI (Italian document for the assessment of interference risks); Correct implementation of COVID-19 contagion containment protocols.

[2] In this regard, the proposed system can operate in symbiosis with the approach discussed in Cina et al., 2019 (60).

The report and statistical sections have been respectively structured to make it possible to:

- send immediately reports containing indications of any discrepancies to the super user at the end of each tour;
- analyze of the evolution of reports and types of discrepancies in subsequent tours and comparison of the same also between virtual tours conducted in different offices or departments of the same company.

The data collected during the inspections in the 21 Companies were subsequently analyzed in terms of:

- time savings compared to the traditional paper approach;
- reduction of the non-given answers (using the report and statistical sections);
- reduction of reported non-conformities resulting from the direct solving of the identified criticalities (using the platform/app statistical section and also the 2 proportions test in Mintab®).

3. Results and Discussion

The following bullet points summarize the main results obtained thanks to the in-situ implementation of the methodology:

- The percentage of the reduction of the time used to compile the check list, compared to the traditional paper approach (the percentages also take into account the time necessary to report any non-conformities to the manager in charge and the time storage) was almost 80%;
- The remedial actions' time (time that elapses from the moment in which a non-conformity is detected to the moment in which it is resolved), is significantly reduced compared to an approach based on traditional paper checklists, thanks to the direct and immediate communication from who detects to who has the task of solving the non-conformity;
- As a direct consequence of the time reduction needed to carry out all the activity of control and correction of any deviation and the possibility, thanks to the guided performing of the controls, to also include personnel who is not highly qualified, the frequency of checks can be considerably increased. For example, with reference to a sample company, the increase was almost 600% (value due to the widespread use of the app from a single department to the whole company) the first year, 2018, and 26% the second year, 2019, as shown in Figure 6;
- Reduction of the non-given answers following a greater awareness and increase of the safety's culture by those who carry out the control tours (Figure 7);
- Reduction of reported non-conformities resulting from the direct solving of the identified criticalities. The examples of Figure 8 and 9 suggest that in a department of a sample company there was a general decrease of non-conformities over the years.

In addition, the 2 proportion tests were performed with data illustrated in Figures 8 and 9, by using the total yes responses (compliance) as number of Events and the sum of the total responses (yes, no and no response) as number of trials N. This test determines whether the population proportions of two groups differ, by comparing the p-value to the significance level. A significance level of 0.05, which indicates a 5% risk of concluding that a difference exists when there is no actual difference, was chosen for this test. The p-value was calculated using the normal approxima-

Figure 6. *Annual trend (2017 is the reference year without the application of the methodology) of the number of Virtual Tours performed in a sample company (graph generated in the statistics section). Translation from the original Italian output*

Figure 7. ***Virtual Tour annual trend of control in a sample company: (graph is generated in the statistics section). Translation from the original output in Italian***

Figure 8. ***Annual trend of compliance and non-compliance percentages relating to a department of a sample company (graph is generated in the statistics section). Period from 03/05/2018 to 10/05/2019. Translation from the original output in Italian***

Figure 9. ***Annual trend of compliance and non-compliance percentages relating to a department of a sample company (graph is generated in the statistics section). Period from 03/05/2019 to 10/05/2020. Translation from the original output in Italian***

tion method and Fisher's exact method in Minitab®. The Minitab® output of the test is illustrated in Table III below:

Table III. ***Minitab® output of the 2 proportions test***

Test and CI (confidence interval) for Two Proportions

Method

p_1: proportion where Sample 1 = Event

p_2: proportion where Sample 2 = Event

Difference: $p_1 - p_2$

Descriptive Statistics

Sample	N	Event Sample	p
Sample 1 (data from Figure 8)	1890	1586	0.839153
Sample 2 (data from Figure 9)	1575	1441	0.914921

Estimation for Difference

Difference	95% CI for Difference
-0.0757672	(-0.097312; -0.054222)

CI based on normal approximation

Test

Null hypothesis	H_0: $p_1 - p_2 = 0$	
Alternative hypothesis	H_1: $p_1 - p_2 \neq 0$	
Method	Z-Value	P-Value
Normal approximation	-6.89	0.000
Fisher's exact		0.000

Because the p-values for both methods are less than 0.001, which is less than the significance level of 0.05, the decision is to reject the null hypothesis (the difference between the population proportions ($p_1 - p_2$) equals the hypothesized difference (0)) and conclude that the difference between the proportions of the two periods, is statistically significant.

4. Conclusion

The substantial changes of recent years in the technical and organization system of industrial production in many NACE sectors, and the changed roles of all the people involved, make necessary new approaches to the Occupational Risk Assessment and Management. Systematic checks and continuous improvement of the situation, special for the changed context, play a basic role, and a quality approach becomes even more important.

The development of this original application for OS&H can contribute to evolve and modernize the infield inspection and control phases, with undeniable advantages in terms of efficiency and effectiveness. Obviously, also in this case the quality of the result depends, as for any Checklist, on the reliability of the Occupational Hazard Identification and Risk Assessment preliminary phases.

However, it is not a system control software, and does solve the identified non-conformities. This goal, currently covered by a different software special for maintenance, will in future be implemented, so that, based on reports and statistics generated by the platform, the superusers will also charge specific subjects of the management of non-conformities and record the closure of the problem, within the same IT environment.

Moreover, a nearly completed *"internal video call to the application"*, will enable an operator carrying out a control tour to contact a referee or consultant without exiting the tour, and to receive information and support. This will become a particularly significant feature in case of maintenance activities: the maintenance crew will find, in the same environment, checklists, manuals and procedures. Moreover, video call capabilities will make possible to remotely ask for technical information, and forward frames of the faulty component for immediate support.

The application for the OS&H checks in companies discussed in this paper, constitutes a modern and time / moneysaving approach, and allows effective guided independent inspections or, if necessary, verification interaction and real-time implementation by experts. The possibility to directly forward reports makes possible the just in time management of occasional non-conformities, the verification of the layout of working areas, the revision of the training of workers charged of specific tasks, and comparative assessments of the various situations over time or in departments or similar production units.

The reduced duration of each inspection makes moreover possible, within the same budget, a substantial increase of the inspections' frequency, reducing the possibility of persistence of non-conformities.

In addition, the approach intrinsically favors the participation of workers and supervisors in the prevention and protection activities, promoting a process of continuous improvement of their expertise, and contributing to the effectiveness and quality of the OS&H audits.

The proposed technique can then contribute in innovative terms to the actions aimed at promoting the dissemination of the Culture of Safety.

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MEDICINA DEL LAVORO

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Health status of petrochemical workers: a narrative review

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ABSTRACT. Professional exposure to benzene has been extensively investigated by occupational medicine, leading to strict regulation of exposure threshold values. However, the petrochemical industry utilizes many chemical substances, whose exposure, without effective control and mitigation actions, could influence the health status over time.
The aim of this narrative review is to describe health status of petrochemical workers related to occupational exposures, inquiring literature from 1980 to present. We used the PubMed and Web of Science search engines. As regards non-neoplastic diseases, despite heterogeneous prevalence estimates, we could say that standardized mortality rate (SMR) for hypertension, hypercholesterolemia and diabetes does not increase overall, compared to reference populations; a possible explanation may be the "healthy worker effect". Attention should be paid to color disperception and respiratory symptoms, due to toxic or irritating substances exposure. Studies concerning neoplastic pathology have mainly investigated mortality outcomes, finding no increase in cancer, except for melanoma or other skin cancers and leukemia. As regards the former, however, it is not excluded that other risk factors may contribute (e.g. UV rays in offshore workers), while for leukemia, only the most recent studies have analyzed various subtypes of hematopoietic tumors, highlighting a possible risk for the development of myelodysplastic syndrome. The risk of pleural mesothelioma was also increased, likely due to asbestos exposures, while the risk of death from prostate cancer remains controversial.

Key words: *refinery, health, workers, petrochemical, respiratory, visual, auditory, neoplastic, non-neoplastic.*

RIASSUNTO. STATO DI SALUTE DEI LAVORATORI DEL SETTORE PETROLCHIMICO: UNA REVISIONE NARRATIVA. L'esposizione professionale al benzene è stata ampiamente studiata nell'ambito della medicina occupazionale, portando a una rigida regolamentazione dei valori soglia di esposizione. Tuttavia, l'industria petrolchimica impiega molte sostanze chimiche, la cui esposizione, in assenza di misure di controllo efficaci, può influenzare lo stato di salute. Lo scopo di questa revisione narrativa è descrivere lo stato di salute dei lavoratori del settore petrolchimico relativamente alla loro esposizione professionale, revisionando la letteratura dal 1980 ad oggi. Abbiamo utilizzato i motori di ricerca PubMed e Web of Science. Per quanto riguarda le malattie non neoplastiche, nonostante eterogenee stime di prevalenza, si può affermare che il tasso di mortalità standardizzato per ipertensione, ipercolesterolemia e diabete non appare complessivamente aumentato rispetto alle popolazioni di riferimento; una possibile spiegazione potrebbe essere legata all'effetto "lavoratore sano". Occorre prestare particolare attenzione all'alterata percezione dei colori e ai sintomi respiratori dovuti

Introduction

Exposures to petroleum derived chemicals have steadily decreased over the years, since the half of last century, even due to regulations of occupational exposure levels to benzene and other air pollutants introduced over the decades (1-3). Data on benzene toxicity has guided to an increasingly active monitoring of exposure levels, environmental remediation and using personal protective equipment. This led to a decrease in pathologies strictly related to the inhalation of high doses of benzene and opening the research towards the impact that lower doses of this compound could have on health. Moreover, risk factors related to a sedentary lifestyle or shift work are always present in some job categories within petrochemical industry. All these issues reflect in difficult investigations, being mostly conducted on company health surveillance databases, often not containing exhausting medical information. Furthermore, information on the workers' disease state are often difficult to be linked to environmental sampling data, therefore leading to exposure levels estimated on self-reported work history. On the other hand, most epidemiological studies on workers in the oil processing industry have been conducted to address the problem of the carcinogenicity. The aim of this narrative review is to give a general overview on health status of petrochemical workers, exposed to several carcinogenic substances, to possibly provide an orientation on further studies for monitoring workers' health status within oil refining plants.

Methods

The narrative review was conducted searching the PubMed and Web of Science databases to identify studies addressing the health of petrochemical workers, published in peer-reviewed journals. Search strings were based on the topic of interest and included keywords such as: health, refinery, work or worker, petroleum or petrochemical, oil, cardiovascular, respiratory, mortality, surveillance; all the words have been combined in various ways (see Supplementary Material). The time period considered ranged from 1980 to 2021. Specific references cited by the articles, found through the listed research methods, were also con-

all'esposizione a sostanze tossiche o irritanti. Gli studi relativi alla patologia neoplastica hanno principalmente indagato gli esiti di mortalità, non trovando alcun aumento del rischio, ad eccezione del melanoma o di altri tumori della pelle e della leucemia. Per i primi, tuttavia, non è escluso che possano contribuire altri fattori di rischio (es. raggi UV nei lavoratori delle piattaforme petrolifere), mentre per le leucemie solo gli studi più recenti hanno approfondito le analisi relativamente ai diversi sottotipi di tumori ematopoietici, evidenziando un possibile rischio per lo sviluppo di mielodisplasia. Risulta aumentato anche il rischio di mesotelioma pleurico, verosimilmente legato all'esposizione all'amianto, mentre resta controverso il rischio di morte per cancro alla prostata.

Parole chiave: raffineria, salute, lavoratori, petrolchimico, respiratorio, visivo, uditivo, neoplastica, non-neoplastica.

sidered. We excluded articles covering the following topics: petrol pump workers, psychological status of workers and the Work Ability Index, other materials refineries (e.g. copper, nickel, aluminum) and health status of people living near petrochemical plants. Research ended on 31/12/2021.

Results

We found 933 results through the search strings. After a selection based on title and abstract content, we have identified 42 relevant primary studies or meta-analysis. Main findings are reported below.

NON-NEOPLASTIC PATHOLOGIES

Data coming from a large health surveillance project at 14 Shell refineries (4) reveal that, among 12,089 male employees, the five most common disease categories (72% of all absences lasting over 5 days) were: wounds/injuries (24.8%), respiratory diseases (16.7%), skeletal disorders (14.1%), digestive system diseases (9.1%) and hearth diseases (6.8%). As regards female workers (2,081), genitourinary diseases (9.9%) replaced hearth diseases (2.7%) in the top five categories. Workers in the production subgroup showed higher sickness rates than workers belonging to administrative and staff personnel. In general, the probability of an illness/absence was higher in subjects who had previously experienced long-term absences, in older workers, smokers and employees with health risk factors (high blood pressure, hypercholesterolemia and obesity). In 8 years of surveillance, 535,487 work days were lost due to illness events lasting over five days.

A ten-years retrospective study on 439 male workers of an Italian (5) refinery showed an increase in BMI values over the years (2000: 26.5 kg/m^2, 95%CI: 26.2-26.8 kg/m^2 – 2010: 27.4 kg/m^2, 95%CI: 27-27.7 kg/m^2), in particular for obesity (BMI≥30; 2000: 11% – 2010: 19%), while the number of subjects with hypercholesterolemia has slightly decreased over the years (2000: 30% – 2010: 23%), even though subjects with borderline levels (200-239 mg/dL) increased (2000: 31% – 2010: 39%). Unlike what observed in this study, the prevalence of hypertension in workers of a Brazilian refinery (6) increased between 2008 (27.2%) and 2017 (35.2%) (the prevalence of diabetes also underwent a growth trend, albeit not statistically significant: from 5.3% to 6.4%), while a decrease in prevalence of high cholesterol (14.7% to 11.6%) and cigarette smoking habits (8.4% to 3.8%) occurred. Specifically, shift workers showed a greater risk of hypertension (OR=1.33; 95%CI: 1.23-1.43) and high LDL cholesterol levels (OR=1.06; 95%CI: 0.99-1.14) than workers with fixed hours; the latter, on the other hand, showed a greater risk of prevalence as regards diabetes, cigarette smoking and arterial risk factors. In another analysis, shift petrochemical workers seem to have indeed an increased risk of metabolic syndrome (according to NCEP-ATPIII definition; OR=2.38; 95%CI: 1.13-4.98) compared to day workers, with higher levels of triglycerides and lower levels of HDL-C; however, no significant difference emerged in terms of BMI, blood pressure and total cholesterol (7). In an Iranian investigation, carried out on eight petrochemical plants, the multivariable regression model returned an increased risk of gastrointestinal disorder in shift workers (OR=1.52; 95%CI: 1.20-1.93) while no association emerged for cardiovascular health problems at the univariate analysis (8).

In another survey, benzene exposed workers showed an higher prevalence of hypertension compared to age/sex-matched unexposed group (30.5%; OR=2.44; 95%CI: 1.24-4.85); this observations was similar for the group exposed both to xylene and benzene (27.9%; OR=2.00; 95%CI: 1.11-3.61) (9). The prevalence of hypertension and its relation to noise exposure were investigated in a group of Brazilian refinery workers: 430/1729 subjects were found to be hypertensive (PAS≥140 mmHg of PAD≥90 mmHg), of which 12.7% were already under treatment. There seemed to be an association between hypertension and noise exposure: using the ≤75dB exposure as reference category, the risk of hypertension significantly increased in accordance with noise level ($OR_{75\text{-}85dB}$=1.56; 95%CI: 1.13-2.17 – $OR_{\geq 85dB}$=1.58; 95%CI: 1.10-2.26).

In an Italian cross-sectional study (10), conducted on 1,073 male workers, it was noted that the percentage of obese (BMI≥30) men over 53 years was higher than the national male estimates (27.5% *vs* 15.5%) and the condition of overweight or obesity affected more than half of the sample (62.4%). Just over a third of subjects (35.5%) had a condition of hypertension (which increased over 50% in the >53 years aged group) as well as high levels of triglycerides (29.7%), or cholesterol levels (24.3%); however, these data were in line with those of the general population.

A study conducted in Saudi Arabia (11) has for the first time investigated the potential association between prediabetes or type 2 diabetes with some occupational categories. It was found that the prevalence of prediabetes (HbA1c: 5.7-6.4%) in refinery workers (n=217) was 36.86%, while that of type 2 diabetes (HbA1c> 6.4%) was 16.12%; HbA1c levels were significantly higher in the exposed group compared to controls. It would seem that exposure to air pollutants can contribute to some degree of inflammation and also to oxidative stress, which is involved in one of the mechanisms of insulin resistance development. However, lower prevalence of diabetes (glu-

cose>126 mg/dL) were observed in other studies, ranging from 2% to 10% depending on the years (5,6,10).

Respiratory system

Petrochemical derivatives are a complex mixture of aromatic hydrocarbons with high volatility and can reach the deepest parts of the lungs, potentially resulting in an alteration of properties and concentration of the surfactant in the respiratory tree and contributing to the closure of small airways. What emerged in a refinery in Saudi Arabia (12) would seem to support this consideration with significantly reduced values of FEV_1 (Forced Expiratory Volume in the 1st second; Exposed: 3.08±0.16 L/s – Control: 3.99±0.14 L/s), Tiffeneau index (67.19±3.15 *vs* 76.66±2.01%), PEF (Peak Expiratory Flow; 4.80±0.37 *vs* 6.89±0.34 L/s), $FEF_{25\%}$ (Forced Expiratory Flow at 25% of FVC; 4.45±0.36 *vs* 6.39±0.33 L/s), $FEF_{50\%}$ (3.65±0.36 *vs* 6.39±0.33 L/s) in subjects considered exposed to benzene. Similar findings were observed in 80 refinery workers in Macedonia (13): a greater prevalence of respiratory (33.7% vs 22.5%) and nasal symptoms (36.2% vs 23.7%) emerged in subjects considered as exposed compared to subjects of the public administration. There was also a decrease in spirometry values: MEF_{50} (equivalent to FEF_{50}) (61.9% of predicted vs 67.4%) and in MEF_{75} (56.1% of predicted vs 62.9%), even stratifying by smoking habits. On the other hand, the prevalence of asthma (control *vs* exposed: 3.7% *vs* 5.0%), allergic rhinitis (control *vs* exposed: 10.0% *vs* 16.3%) and allergen sensitization (control *vs* exposed: 31.2% *vs* 35.0%) was found to be in line with data relating to Macedonian adult population.

The responses to a questionnaire from 5,983 workers within a petrochemical complex comprising 75 companies (refinery, production of organic chemicals compounds, synthetic rubber, fertilizers) highlighted an increased risk of having phlegm, wheezing or shortness of breath in smokers and subjects with a previous history of respiratory diseases or atopy, as well as in those who have declared to handle toxic materials (e.g. powders, metals, organic solvents and vapors; overall OR_{phlegm}=1.39; 95%CI: 1.11-1.73 – $OR_{wheezing}$=1.71; 95%CI: 1.31-2.44 – $OR_{shortness\ of\ breath}$ =1.80; 95%CI:1.37-2.38) and in those who did not wear or wear incorrectly protective devices (OR_{cpugh}=2.47; 95%CI: 1.21-5.06 – OR_{phlegm}=2.05; 95%CI: 1.29-3.27 – $OR_{wheezing}$=3.03; 95%CI: 1.65-2.43 – $OR_{shortness\ of\ breath}$ =2.05; 95%CI: 1.17-3.60). This study did not reveal an increase in the onset of respiratory symptoms in relation to the duration of work (set at ≥8.3 years on the basis of sample average), however the subdivision of the exposure values based on the job performed and aerial levels of compounds in the various structures is not clear (14).

Using two validated questionnaires, spirometry and FeNO measurement, in a cross-sectional study conducted in Algeria emerged a significant increased prevalence of respiratory and nasal symptoms in workers exposed to benzene, toluene, ethylbenzene and other compounds, employed in a hydrocarbons distribution company. Odd-ratios, adjusted for age, BMI and smoke, range approximatively form 2 to 10; even after additional adjustment for reported allergy, the main symptoms keep statistical significance (e.g. $OR_{cough,\ last\ 12\ months}$=3.25; 95%CI: 2.0-5.2 – $OR_{phlegm,\ at\ least\ 3\ months/yr}$=3.81; 95%CI: 1.9-7.6 – $OR_{breaths\ at\ rest,\ last\ 12\ months}$= 12.5; 95%CI: 3.7-41.4 – $OR_{asthma,\ last\ 12\ months}$=3.95; 95%CI: 1.3-12.2 – $OR_{nasal\ symptoms,\ throughout\ the\ year}$=3.96; 95%CI: 1.4-11.4). Authors observed, even after excluding subjects with rhinitis, a significant reduction of Tiffeneau index (81.9±8.6% *vs* 83.8±6.8%) and MEF_{25} (95.6±41.8% *vs* 105.8±49.7%) in exposed workers, as well as for others parameters, but without statistics relevance as regards the latter. Values of FeNO were significantly higher among exposed workers, both with and without adjustment for age, height and smoking category (15).

Visual and hearing system

The harmful substances present in the working environments of petroleum derivatives, inhaled in closed or poorly ventilated environments, especially if mixed with other impurities, can lead to disturbances not only of the respiratory system, but also of the nervous system (organic solvents can accumulate in organs rich in lipids): for example alteration of the visual and auditory system. In fact, organic solvents have been shown to be responsible for alterations in several components of the visual system, including the lens, retinal layers and the optic nerve. Occupational exposure to solvents such as styrene, toluene, n-hexane, carbon disulfide has been indicated as a possible causal event of acquired dyschromatopsia (16-18). In a Korean refinery (19) researchers saw an increase in the prevalence of dyschromatopsia, especially type III (concerning the perception of blue-yellow colors). Prevalence in left eye of workers without exposure was 22.7%, 24.0% in workers with low exposure, 26.5% in subjects with medium exposure and 30.2% in workers with high exposure; environmental pollutants were below the risk limit threshold, with the exception of benzene which was found to be on average 102% of the TLV. Using the CCI (Color Confusion Index) as parameter, it emerged that the level of exposure and duration in working years appeared to be statistically associated with the presence of type III dyschromatopsia in the left eye, even though this association was very weak (Spearman's correlation=0.131). The loss of color discrimination was also very weakly associated with chronological age (it should be noted that subjects with the highest exposure were also those with higher age). Similar disperception was weakly observed in 30 workers of an Indian refinery: blue-yellow vision defects were found in 16 of 30 workers *vs* 7 of 30 age-matched reference group. Furthermore, the Color Confusion Index (CCI) was higher in exposed than in unexposed (1.40±0.18 vs 1.28±0.21; p=0.037) (20). This latter association was not found in the study by Lee et al (except for not significant increase in the left eye) but only between CCI and age (p=0.002) (19).

Regarding the hearing system, it has been suggested that the association between chemical solvents and noise could have an additive effect even if levels are low or moderate (21,22). Morata et al (23) tried to evaluate a possible difference in the prevalence of hearing disorders

among workers of a refinery in South America, through audiometric and acoustic immittance tests: most of the toxic compounds (such as toluene, xylene, cyclohexane ethylbenzene) were found to be below exposure threshold levels in the various subgroups of workers, with the exception of benzene, which was found to be on average over-threshold for subjects involved in maintenance, refining of aromatic compounds and paraffins and workers in the internal laboratory for quality control. The result was a greater hearing loss at high frequencies in subjects considered to be more exposed to pollutants and noise (compared with reference categories not considered exposed due to environmental sampling with values below the detectable threshold for the pollutants analyzed; $p<0.005$). From the multiple regression model it was also observed that the risk of hearing loss was 3 times greater in maintenance subjects, again compared to the categories considered not exposed to noise or pollutants (95%CI: 1.3-6.9) and almost two and a half times higher in subjects operating in the refining of aromatics and paraffins (95%CI: 1.0-5.7). Subjects belonging to the subgroup of aromatic compound refinement and pipe-fitting, showed a significantly higher percentage of cases of decay of the acoustic reflex. Results, also considering the greater loss of reflex due to ipsilateral rather than contralateral stimulation, suggest that there may be retrocochlear involvement in the acoustic disturbances observed and that hearing loss may therefore not be attributable simply to cochlear damage following acute acoustic trauma or chronic.

A more recent Chinese study investigated the effect of combined exposure to noise and ethylbenzene in two refinery group workers compared to an unexposed group and to power station workers. Using the Neurobehavioral Core Test Battery, ia decrease in some of the function inspected, especially in people with 3 or more working age, was observed. There was also an increased risk of hearing loss ≥25 dB in the two petrochemical groups, but the estimate was not precise enough to get a conclusion (age-adjusted OR_1=107; 95%CI: 17.1-358 – OR_2=114; 95%CI: 34.2-343) (24).

Mortality

As regards cardiovascular diseases mortality, a study carried out on a cohort of 1,583 workers of an Italian refinery (25) showed a lower risk of death (SMR=0.77; 95%CI: 0.64-0.93) compared to the general Lombard population (period 1949-1968). This result was in line with a previous study (26) conducted on workers of the same refinery, in which no increased risk emerged by comparing the sample with the Italian national population (SMR=0.88; $CI_{95\%}$: 0.68-1.12) and with the Lombard one (SMR=0.68; $CI_{95\%}$: 0.53-0.87). A further study (27) confirmed this mortality reduction (SMR=0.70; 95%CI: 0.63-0.78). Same mortality (SMR=0.90; 95%CI: 0.87-0.92) was found by a broader temporal analysis considering 28,555 employees who had worked at least 12 months from 1951 to 2003 in 8 refineries located in England, Scotland and Wales, using national population as reference. A significant reduction also emerged analyzing 2,203 workers employed between 1990 and 1998 in a chemical/refinery plant in Louisiana (OR=0.83; 95%CI: 0.72-0.94) (28) and also an older cohort of refinery and petrochemical Shell Oil Company workers (working period: 1948-1972; SMR 0.80) (29). A slight discrepancy from previous estimates was instead observed within a cohort of Canadian refinery workers, in which there seems to be an increase in the standardized mortality rate for arteries, arterioles and capillaries disease, compared to national population (SMR=1.31; 95%CI: 1.09-1.56). On the other hand, these workers showed a decreasing risk for acute myocardial infarction (SMR=0.84; 95%CI: 0.77-0.93). Aortic aneurysm mortality showed an insignificant increase for these refinery workers (SMR=1.21; 95%CI: 0.89-1.62), while it was for marketing and distribution sector ones, potentially exposed to petroleum products (SMR=1.56; 95%CI: 1.11-2.12) (30); in a previous study, mortality from diseases of the arteries was increase in the refinery subgroup (SMR=120; 95%CI: 107-135) (31).

Among three of the Italian (25,27) and English cohort (32) analyzed above, respiratory (SMR=0.54, 95%CI: 0.29-0.92; SMR=0.59, 95%CI: 0.44-0.78, SMR=0.76, 95%CI: 0.72-0.81 respectively) and gastrointestinal diseases mortality (SMR=0.54, 95%CI: 0.33-0.84; SMR=0.55, 95%CI: 0.42-0.71, SMR=0.80, 95%CI: 0.72-0.90 respectively) was decreased compared to the reference population.

Finally, within a cohort of 7,147 workers at a petrochemical plant in Southern Italy, the SMRs observed for cardiovascular (SMR=0.57; 95%CI: 0.50-0.65), respiratory (SMR=0.61; CI95%: 0.46-0.82) and gastrointestinal diseases (SMR=0.50; 95%CI: 0.38-0.65), calculated for 6,458 subjects with a follow-up of at least 10 years, were lower than the reference population (33).

NEOPLASTIC PATHOLOGIES

Data relating to malignancies mostly focus on mortality rates. Results of most of the studies in literature have been already summarized in some meta-analyzes. Published in 1989, a systematic review and meta-analysis of epidemiological studies on oil workers examined different types of solid and hematopoietic tumors (34): overall, there was no significant increase in mortality from any type of cancer in the oil industry. However, an increased risk of cancer mortality has been described in some small groups of petrochemical industry workers for the following cancers: prostate cancer in workers of methylethylketone (MEK) units in two US refineries, kidney cancer in petrol tanker drivers in a UK study, and melanoma in two out of eight UK refineries. Additionally, an increased risk of leukemia has been reported in three cohorts of workers within US refineries, especially those employed in the 1940s or earlier. No increased mortality was found for other types of cancers. These results were consistent with the evaluation of the International Agency for Research on Cancer (IARC, 1989): limited evidence for skin cancer and leukemia risk due to oil refineries, while inadequate evidence for other types of cancer (35). The authors stressed the lack of specificity of the analysis within the broad category of hematopoietic tumors in cohort studies: for instance, leukemias had not been analyzed for specific cell type. In addition, other hematopoi-

etic cancers, such as non-Hodgkin's lymphoma (NHL) and multiple myeloma (MM), were not debated in most cohort studies. Nevertheless, subsequent systematic reviews and meta-analyzes of multiple myeloma and non-Hodgkin's lymphoma (36-38) did not reveal an increased risk of these hematopoietic tumors following occupational exposure to benzene or other petroleum products containing it. An update of this review (39), including a cohort of over 350,000 petrochemical workers, concluded that there was no increase in mortality from gastrointestinal cancers (stomach, colon, liver or pancreas), from pulmonary, bladder, kidney and brain tumor cancers. The summary standardized mortality ratios for each tumor type were below unity.

Association with Non-Hodgkin Lymphoma (NHL) and benzene was observed in a more recent meta-analysis, even after adjusting for the "healthy worker effect" (40). The summary relative risk for the 21 refinery studies analysed was 1.21 (Shore-adjusted 95%CI: 1.00-1.46) and 1.42 (Shore-adjusted 95%CI: 1.19-1.69) after adjusting for the healthy worker effect. Even after removing the largest sample size study or the one with the greater relative risk, the overall effect was confirmed. Considering only the 14 studies that assessed a higher exposure working category, the summary Relative Risk (RR) increased to 1.51 (Shore-adjusted 95%CI 1.07-2.14). This evidence is in contrast to what observed in a previous meta-analysis (41), which however not considered only refinery industries. It should be pointed up that some old studies report only risks for lymphosarcoma and reticulosarcoma, subcategories of NHL. Even Kane et al (42) highlighted the lack of association between gasoline exposure (not only refinery plants where considered) and NHL risk, with an overall risk, calculated with random effects analysis, of 1.02 (95%CI: 0.94-1.12. I^2=24.7%, p=0.077). The subtotal pooled risk for refinery and petrochemical plants resulted of 1.00 (95%CI: 0.91-1.09. I^2=0.0%, p=0.554).

Significant increases in melanoma mortality have been reported in some small groups of UK refinery workers (SMR=1.78; 95%CI: 1.20-2.54) and Canadian upstream ones (SMR=6.00; 95%CI: 2.19-13.06) (43,44), but responsible agents have not been identified. However, none of the US cohort studies described a significant increase in skin cancer mortality (SMR=1.10; 95%CI: 0.95-1.27) (39). High mortality has been instead described for prostate cancer in short-term workers in a US refinery and in short-term workers employed in some crude oil operations. However, the absence of a growing trend in relation to length of service in these workers argues against the association between exposure to petroleum products and prostate cancer. Out of total oil workers, prostate cancer mortality was not increased (SMR=0.98; 95%CI: 0.94-1.03) (39). More recently, a systematic review and meta-analysis was performed with the aim of updating the IARC and Wong and Raabe reviews: particular attention was paid to mesothelioma, melanoma, and hematopoietic tumors (45). Studies using the most appropriate methods for case identification provided the best estimate of mesothelioma risk (meta-RR=3.22; 95%CI: 1.45-7.23), while a higher meta-RR was found in maintenance workers. A modest relative excess risk was found for acute lymphatic leukemia (ALL) (meta-RR: 1.51; 95%CI: 1.08-2.13) and melanoma (meta-RR: 1.23; 95%CI: 1.09-1.38). The relative risk for ALL was influenced by results of a large study, with some suspicion of diagnostic uncertainty, and the relative excess risk for melanoma was linked to two large studies on incidence. Furthermore, refinery workers may have a lower risk of lung cancer (meta-RR: 0.81; 95%CI: 0.76-0.86). The increased incidence of melanoma emerged in another meta-analyses (Standardized Incidence Rate or SIR=1.23: 95%CI: 1.11-1.36), but there is less evidence regarding mortality (SMR=1.02; 95%CI: 0.81-1.28), although the male subgroup analysis showed a greater association (SMR=1.19; 95%CI: 1.00-1.42). Regarding mortality, there appeared to be an association with the latitude of the Country in which studies were conducted (46).

In a mortality study conducted on a cohort of 5,112 male workers employed in Italian petrochemical plants, between 1949 and 2011 (average follow-up length of 49 years), the SMRs were calculated using regional rates, specific for age and gender (27). In the whole cohort there was an increased mortality for pleural mesothelioma (SMR 1.59; 95%CI: 0.71-3.53), brain tumor (SMR 1.47; 95%CI: 0.87-2.49) and lymphatic leukemia (SMR 1.81; 95%CI: 0.91-3.62), but without statistical relevance. All deaths from pleural cancer occurred after more than 10 years of latency and in workers with duration of exposure ≥20 years, while those from brain tumors occurred in workers with latency and duration of exposure <10 years. Cases of lymphatic leukemia, especially chronic type, involved workers with latency and duration of exposure ≥20 years. Four fatal cases of acute myeloid leukemia (AML) were observed in the group with latency ≥20 years (SMR 1.55, 95%CI: 0.58-4.12). A recent pooled analysis (47) of three case-control studies (48-50), updated with new cases of hematopoietic tumors (total of 370 cases and 1,587 controls), showed that occupational exposure was associated with an increased risk of myelodysplastic syndrome (MDS), but not acute myeloid leukemia (AML). In this analysis, a statistically significant dose-response relationship was found between MDS and benzene exposure, but similar results were not observed with AML; low benzene levels can cause MDS, but higher concentrations may be needed to develop AML. Some studies suggest that immune-mediated inflammation is an early stage in the development of benzene-induced MDS. Since MDS is prevalent in the elderly, the disease could remain at low grade for years and subsequently progress to the stage of full-blown disease with age-related decrease in immune defenses. In contrast, higher concentrations of benzene may be required for acute myeloid leukemia (AML). In this study, it was not confirmed that exposures occurring within 15 years of diagnosis are closely related to AML (or MDS and CML). The question of whether AML is an independent effect or a possible outcome of benzene-induced MDS also remains unanswered (47). Results of a subsequent analysis demonstrated the lack of association between benzene and chronic lymphocytic leukemia

(CLL) (51). Nevertheless, some studies identified elevated CLL mortality in petrochemical plant workers before 1950. As refineries represent a complex exposure environment, co-exposure in addition to benzene could contribute to the etiology. Finally, it must be said that previous studies probably reported an excess of cases of AML or aplastic anemia, rather than an excess of cases of MDS, since the diagnostic criteria for the last had yet not been defined (47).

In addition to cancer risk in residents living near petroleum facilities, the most recent meta-analysis has taken into consideration specific ones for workers within them. As in other studies, reduction in lung cancer risk was confirmed, although there was a strong heterogeneity between the included studies (SMR=0.82; 95%CI: 0.76-0.88) as well as the risk for mesothelioma (SMR 1.98; 95%CI: 1.46-2.67); this one is probably associated, in most cases, with exposure to asbestos, used in combustion petroleum pipes. Within the offshore workers sub-category, the risk of cutaneous melanoma (without statistical significance), leukemia (OR=1.47; 95%CI: 1.12-1.92), lung (OR=1.20; 95%CI: 1.03- 1.39) and mesothelioma (OR=2.47; 95%CI: 1.66-3.67) were increased, even though many of these associations appear to be due to other factors than those directly emerging from petroleum production (52).

Discussion and Conclusion

In the oil sector there are various risk factors which, in the absence of mitigation and control measures, can affect the health of workers. The presence of incorrect eating behavior, characterized by an excessive intake of high-calorific food, and work-related stress components, constitute important risk factors for the onset of cardiovascular diseases. From studies in literature, it was possible to note a slight increase in blood pressure, cholesterol and BMI values in petrochemical industry workers, but not evenly. The concept of promoting a balanced diet to reduce the onset of cardiovascular and metabolic diseases, as experimented in other industrial sectors (53), could therefore be extended to the oil industry, even to increase efficiency of labour. Greater attention to cardiovascular and coronary diseases should be given among shift workers (6,54,55). In almost all epidemiological studies concerning the occupational field, selection bias known as the "healthy worker effect" could underestimate the risk due to environmental pollutants. A possible strategy to minimize the effect of this bias could be to use as reference category a workers cohort, instead of general or local population (56). Along with others such as length and degree of exposure and limitation of the number of people included in the studies, this critical issue had already been highlighted in a literature review conducted more than 30 years ago on 120 articles (57).

The possible involvement of air pollutants with development of conditions of oxidative stress and inflammation make it necessary to continuously monitor the indices of predisposition to cardiovascular damage and the onset of diabetes; for the latter condition, more in-depth and targeted investigations should be conducted in this category of workers. The use of glycated hemoglobin would make it safer to determine a condition of diabetes or prediabetes, however it is a second level test in clinical practice, therefore annual blood glucose monitoring can still provide data that can be used to evaluate the general trend of the state glycaemic levels in workers and possibly correlating it with the role of environmental pollutants in refining plants.

As regard neoplastic pathologies, it has been observed an overall reduction in relative or mortality risks, likely explained by the "healthy worker effect". Some exceptions were found in specific studies, maybe linked to particular cohort of subjects or to higher level of environmental pollutants. Considering the variety of volatile compounds present in petrochemical plants, it is often difficult to demonstrate the association of each ones to a specific type of tumor, hence the desire to give a general overview of cancer risk in this industrial sector. Help comes from in vitro or animal studies, which linked the exposure to a single chemical compound with a specific neoplasm, even though the additive effect of other pollutants present in the workplace cannot be excluded. The increased risk for certain type of cancers, for example mesothelioma or lung, could not be closely related to exposure to substances derived from benzene but to materials such as asbestos, for a long time present in industrial sector, therefore also in petrochemical plants (58-60). Furthermore, in older studies, some categories of haematopoietic tumors did not have the same current classification, creating a certain difficulty in comparing the trend of these diseases. For example, MDS diagnostic criteria were recently defined, and it seems to be a relationship between benzene exposure and this syndrome (61), even at low doses, so new studies on petrochemical workers should be implemented. Overall, the association between benzene exposure and leukemia is confirmed by various studies in the literature (62) while there is heterogeneity in risks for the different type of leukemia (AML, CML, CCL), maybe linked to different dose exposure (for CCL and AML could be necessary high dose). Otherwise, the association with lymphomas (in particular NHL) is not so clear. Except for some small studies, no association between working in refineries and prostate cancer was found, even though in literature we could find some evidence of association of this neoplasm with BTX exposure (63); the correct use of PPE and environment monitoring, to keep toxic compound below threshold levels, could partially explain these findings.

Major problems, emerging from cross-sectional and retrospective studies analyzed, are mostly linked to data collection through company health surveillance databases, often not conceived for in-depth epidemiological research and without standardized classification systems. Therefore, information obtained could be hardly comparable and sometimes lack in details. Another matter is the low sample size, which could fail in finding precise Standardized Mortality Ratio or Standardized Incidence Ratio (i.e. with wide confidence interval), especially for rare pathologies.

In almost all of the studies analyzed, a univocal opinion emerged on the need to implement workers health monitoring programs through different strategies, such as specific direct examinations or simply medical counseling, also in order to reduce absenteeism due to health problems.

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Supplementary material

Search strings used in PubMed:

- health[Title/Abstract] AND refinery[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- health[Title/Abstract] AND petrochemical[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- cardiovascular[Title/Abstract] AND refinery[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- cardiovascular[Title/Abstract] AND petrochemical[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- respiratory[Title/Abstract] AND refinery[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- respiratory[Title/Abstract] AND petrochemical[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- surveillance[Title/Abstract] AND petrochemical[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- surveillance[Title/Abstract] AND refinery[Title/Abstract] AND workers[Title/Abstract] (1980-2021)
- refinery[Title] AND smok*[Title] (1980-2021)
- mortality oil petrochemical(1980-2021)
- mortality AND oil AND worker AND petroleum(1980-2021)
- mortality[Title/Abstract] AND oil refinery[Title/Abstract] (1980-2021)

Search strings used in Web of Science:

- Refinery (abstract) and health (abstract) and worker*(abstract)
- Refinery (abstract) and cardiovascular (abstract) and worker*(abstract)
- Petro* (abstract) and cardiovascular (abstract) and worker*(abstract)
- Refinery (abstract) and respiratory (abstract) and worker*(abstract)
- Petro* (abstract) and respiratory (abstract) and worker*(abstract)
- Petro* (abstract) and vision (abstract) and worker*(abstract)
- Refinery (abstract) and vision (abstract) and worker*(abstract)
- Petro* (abstract) and hear* (abstract) and worker*(abstract)
- Oil refinery (abstract) and mortality (abstract)
- Petroleum (abstract) and mortality (abstract) and meta-analysis (All fields)

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Exergame for the functional rehabilitation of adults over 55 with neurological diseases

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ABSTRACT. Rehabilitation based on Exergame is showing a rapid evolution, with interesting applications for the recovery of mobility, balance, postural control, coordination and fine motor skills, and including home-based training.
At present, there are no precise indications for Exergame-based rehabilitation of people over 55 affected by stroke, Parkinson's disease, or multiple sclerosis.
This review examines the proposed modalities and the effectiveness of Exergame-based rehabilitation interventions for adults over 55 with stroke, Parkinson's disease or multiple sclerosis, highlighting the limitations, advantages, controversies and impact of this approach.
We examined randomized controlled trials published between 2016-2020, with search in the databases of PubMed, Scopus, Cochrane Library, RehabData, selecting 24 studies.
The study of patients with chronic or subacute stroke in outpatient treatment, and with small sample sizes, prevails.
Wide variability characterizes the rehabilitation methods, the technological platforms used, the type and dose of exercise administered, the outcome measures.
The adequacy and efficacy of Exergames remains uncertain in the neurological elderly, and the functional improvement in the neurological adult patient is not yet attested using this type of approach.

Key words: *Exergame, functional rehabilitation, virtual reality, neurological diseases, outcome measures.*

RIASSUNTO. EXERGAME PER LA RIABILITAZIONE FUNZIONALE DI ADULTI OVER 55 CON MALATTIE NEUROLOGICHE. La riabilitazione basata su Exergame sta mostrando una rapida evoluzione, con interessanti applicazioni per il recupero della mobilità, dell'equilibrio, del controllo posturale, della coordinazione e della motricità fine, comprendendo il contesto dell'allenamento domiciliare.
Al momento, non esistono indicazioni precise per la riabilitazione basata su Exergame di soggetti over 55 colpiti da ictus, malattia di Parkinson, o sclerosi multipla.
Questa revisione esamina le modalità proposte e l'efficacia degli interventi riabilitativi basati su Exergame per adulti over 55 con ictus, morbo di Parkinson o sclerosi multipla, evidenziando i limiti, i vantaggi, le controversie e l'impatto di questo approccio.
Sono stati esaminati studi randomizzati controllati pubblicati tra il 2016-2020, con ricerca nei database di PubMed, Scopus, Cochrane Library, RehabData, selezionando 24 studi.
Prevale lo studio su pazienti con ictus cronico o subacuto in trattamento ambulatoriale, e con dimensioni piccole dei campioni. Ampia variabilità caratterizza le modalità riabilitative, le piattaforme tecnologiche utilizzate, il tipo e la dose di esercizio somministrato, le misure di esito.

Introduction

The use of technology, including exergaming (EG), is rapidly increasing in functional rehabilitation, also of the older adult. Recent studies have highlighted positive aspects regarding the rehabilitation use of this type of technology, diversified and potentially very broad.

EG are video games that combine real-time motion detection and feedback about performance, to promote physical condition and practice of simulated functional tasks. The participant's movements, detected by special sensors or through an external controller, animate an avatar on the screen/monitor representing the player involved in different type of games. Several options of changing the virtual environment and objects, task difficulty level, and adapt the specific task to the user requirements are provided. Minimum risk and ludic aspects of gaming may augment motivation toward motion and fulfilment of objectives. This technology can deliver multisensory, task-oriented exercises that are promising in the rehabilitation process of neurologic disorders. The multisensory feedback boosts motor learning and facilitates cortical reorganisation, thereby facilitating the recovery of functions and activities.

EGs have emerged as therapeutic approaches in clinical settings, providing improvements in the functions of the upper limbs, in daily activities (1,2) and in gait (3) in post-stroke patients and in motor symptoms (4) and balance (5) in patients with Parkinson's disease (PD). EG treatment also allows for long-term exercise planning, which is useful for reducing the impact of multiple sclerosis (MS) related disorders in adults. Commercial interactive gaming system such as Wii (Nintendo, 2006) and Kinect (Microsoft, 2010), designed for an entertaining purpose of a 'typical' healthy user, found to be effective when used in rehabilitation programs to assist in patients' recovery of motor function (6).

The Wii, with variety of games enabled through its peripheral devices (Wii Remote and Wii Balance Board), has been used with the Wii Fit for physical activity conditioning (7) and balance rehabilitation (8) in people with MS (9), stroke (1,10-12) and subacute stroke (13).

The Kinect system, inclusive of hands-free interface device (Kinect sensor) compatible with the Xbox 360 and

L'adeguatezza e l'efficacia degli Exergames rimane incerta negli anziani neurologici, ed il miglioramento funzionale nel paziente neurologico adulto non è ancora attestato utilizzando questo tipo di approccio.

Parole chiave: Exergame, riabilitazione funzionale, realtà virtuale, malattie neurologiche, misure di esito.

Xbox One console, and leveraging the creation or adaptation of new games by open source software, proved reliable for assessment of postural control and training of muscle tone and power in post-stroke patients (14).

EG rehabilitation leads to improvement of gross body (15) and upper body mobility (16), with benefits transferred also to daily activity (17-20), and rehabilitation learning sustained up to 3 (15) and 6 months (21). Effects are particularly evident for EG training applied in addition to conventional therapy, while limited generalizability of results prevents to reach conclusions on mobility outcomes when EG administered alone (19).

Few EG systems have been developed specifically for rehabilitation purposes. Among these, Serious Games are systems involving cognitive and motor tasks, developed to support rehabilitation. Robotic systems, ranging from simpler end effector to more complex exoskeleton, are particularly promising in sensorimotor rehabilitation.

In the practice of occupational rehabilitation, most therapeutic interventions aim at the recovery of function by the adult suffering from diseases such as stroke, PD or MS. The use of rehabilitation technologies based on EG can represent an advantage for the use of resources and for the different possibilities of administering the exercise. Although technological rehabilitation can be generally considered a safe treatment, there is no complete overview of the functional rehabilitation approach with EG for the older adult. Many issues, such as best dose of therapy, timing, and types of programs, individual adaptation of treatment, long-term sustainability of effects, remote administration, safety related concerns, and others, are yet to define clearly.

In this review, we consider the adequacy and efficacy aspects of Exergame treatments for the functional rehabilitation of the adult with stroke, PD, or MS.

Methods

A literature search was undertaken between August and October 2020 in the international online bibliographic databases PubMed, Scopus, Cochrane Library, RehabData, using the keywords: *(exergame OR active video game) AND (elderly OR older adults) AND (rehabilitation OR occupational therapy)*. The identification, screening, eligibility and inclusion of studies were performed following the 2009 Prisma flowchart. Two reviewers (a physician and a research assistant) conducted the search independently. Articles that met the following criteria were included in the review: published since 2016, randomized controlled trial, focusing on the use of exergames or active video games/virtual reality rehabilitation of older adults (mean age ≥ 55 years old) affected by neurological disease (stroke, Parkinson's disease, multiple sclerosis), written in English and with full text available online.

Articles were excluded if they were review, if focused at improving cognitive tasks, considered other pathologies, healthy or frail subjects, or did not describe any rehabilitative intervention.

The title and/or abstracts of the studies were scanned for the study objective, study population, exergame platform, training procedure, measurement. Borderline cases (such as studies with participants' age not fully corresponding to that supposed), were evaluated according to their contribution to knowledge.

A scoring sheet was developed on a Microsoft Excel for the full-text review. Data were sorted in categories, including participants (population, main selection criteria, number of subjects, and participants age), study (methodology, location, and focus), game technologies and exercises (gaming system, games, exercise, playtime, frequency and duration), and measure of evaluation (outcomes and results).

The methodological quality of the included studies was evaluated by a classification system, the Jadad Scale (Oxford quality scoring system) (22) commonly used by the health care community, according to randomization, blinding, and drop out. In this scoping review the methodological quality of the studies did not determine their inclusion or exclusion.

Results

A total of respectively 83 and 50 articles were found in the databases by the two reviewers (searching phase, Aug-Oct 2020), reduced to 30 potential eligible studies after exclusion based on title and abstract (screening phase, November 2020). Disagreements over inclusion was resolved by consensus after referring to criteria and relevant theoretical and empirical issues. Eventually twenty-four studies were eligible by both reviewers, and included in the review (Table I).

All studies, except one with "virtual reality" in the title (24), included keywords such as *exergame, videogame, virtual reality, virtual rehabilitation, rehabilitation games, Nintendo Wii, Kinect, biofeedback, proprioception, balance training-rehabilitation.*

Although our main focus was on EG, we included 18 articles (75%) with "Virtual Reality" in the text and / or in the title. In this review indeed, we use the term virtual reality (VR) referring to EG features.

The studies were published in 2016 (three), 2017 (seven), 2018 (six), 2019 (seven), and 2020 (one), from America (eight), Europe (six), East (seven) and Middle East (three). All studies were RTC, randomized controlled trial, (with five pilot study). The methodological quality of RCTs assessed by the Jadad scale was high in 70% of cases. Majority of studies (fifteen) focused on chronic or subacute stroke (including haemiplegia), eight focused on Parkinson's disease (PD), and one study on multiple sclerosis (MS).

Table I. *Summary of the studies: details of experimental (ExpG) and control (CtrlG) groups, type of intervention and duration, primary and secondary outcome measures, key results, unattained goals, and hints for future investigations* (see common legend)

Study	Participants	Intervention	Outcome measures Primary / Secondary	Key results ExpG	Unattained goals / Drawbacks *Hints for future investigations*
Henrique et al. (2019) Brazil	• Total n. = 31; • Age ExpG (yr) = 76.10 (10.09) • Gender ExpG = 7M, 9F • Pathology = Stroke	**Individual, supervised, outpatient** • ExpG = Protocol based on Piasecki et al. (PEI): exercise simulate 6 activities where user must move hands, upper limb, lower limb and torso during standing, with different difficulty level (30 min PT, 2/wk x 12 wk). • CtrlG = Similar protocol of conventional rehabilitation. (30 min PT, 2/wk x 12 wk).	• Balance = **BBS**. • Upper limb motor function = **FMA**	• BBS and FMA improved significantly in both groups after rehabilitation. • ExpG showed better (non significant) balance results than CtrlG, with the same intervention time. • Significant differences between the two groups, in changes from pre-intervention to post-intervention values (shoulder, elbow, forearm, and total variables), same treatment time.	No improvement in the rehabilitation of the hemiparetic hand. *Evaluate lower limb motor function; Evaluate patient's engagement; Include other pathologies; Intervention group combining the 2 therapies; Interest for multicentric study.*
Ghassabi et al. (2019) Canada	• Total n. = 18 • Age ExpG (yr) = 42.2 (SD 9.3) • Gender ExpG = 5 M, 4 F • Pathology = Stroke	**Individual, supervised, outpatient** • ExpG = Unilateral and bilateral UE training in all planes to perform five UE activities against gravity 2 (min PT, 2 or 3/wk x 4 wk) + Usual rehabilitation (occupational and physical therapy). • CtrlG = Traditional therapy session (occupational and physical therapy) 2 or 3/wk x 4 wk)	• Upper limb motor function = **FMA-UE, BBT**. • Self-reported health status = **SIS**. • Self-reported measure of UE use = **MAL (MAL-AOU, MAL-QOM)**. • Feasibility and safety= session time and adverse event.	• MAL-QOM: significant difference between groups in T1 (post intervention) compared to the CtrlG, but not in T2 (the follow-up) • Significant MAL-QOM score from baseline in ExpG. • Significant difference in mobility domain of the SIS and SIS-Physical between the two groups. • SIS-Total significant changes in ExpG from baseline to post-treatment and were still present at T2.	No recorded finger movements *Need more patients; Stratify patients with different clinical characteristics; Evaluate patients' perception and satisfaction; Understand the relationship between patient characteristics and how gains are maintained over time; Long-term follow-up; Identify the ideal treatment intensity and duration.*
Hung et al. (2019) Taiwan	• Total n. = 33 • Age ExpG (yr) = 56.58 (45.88-64.25) • Gender ExpG = 12M, 5F • Pathology = Stroke	**Individual, supervised, outpatient** • ExpG = Shoulder and elbow movement training to perform 8 games both bimanual and unimanual (30 min PT, 2 or 3/wk x 12 wk) + ADL training (15 min) and conventional hand function training (30 min) • CtrlG = Therapist-based training with variety of bilateral or unilateral UE movement training (30 min PT, 2 or 3/wk x 12 wk).	• Upper limb motor function = **FMA-UE** (PROXIMAL and DISTAL), WMFT-TIME, WMFT-FAS, MAL-AOU, MAL-QOM. • Participation = PPPS, accelerometry.	• No between-groups differences for any scores, either post-intervention or at the 3m follow-up point. • The ExpG showed significant improvements in FMA-UE, FMA-PROX, and FMA-DIS, in WMFT-TIME and MAL (AOU and QOM). • The CtrlG only showed significant improvements in FMA-UE and FMA-PRO and WMFT-TIME. • At the follow-up both groups shows significant improvement in FMA-UE (P=0.011), FMAPROX (P=0.01) and WMFT-TIME, and CtrlG also WMFT-FAS.	Functional gain in MAL not maintained at the 3-month follow-up. *Analyze the low retention effect on the participation domain for ExpG.*
Ferraz et al. (2018) Brazil	• Total n. = 62. • Age ExpG (yr) = 67 (SD 1). • Gender ExpG = 10M, 10F. • Pathology = PD.	**Individual, supervised, outpatient** • ExpG = Strength and muscular endurance, cardiorespiratory fitness, postural balance, and executive function exercise to perform 1 or 2 mini-games repeated in different levels of intensity, each lasts about 3 min. (30 min PT, 3/wk x 8 wk). • CtrlG = functional training or aerobic training on a stationary bicycle with progressively increasing of maximum heart rate. (40 min PT, 3/wk x 8 wk).	• Walking capacity = **6MWT**. • Gait speed = 10MWT. • Lower limb strength and power = SRT. • Body fat composition = BMI and abdominal circumference. • Perception of functional capacity = WHODAS 2.0 • Quality of life = PDQ-39 and EuroQol-5D. • Perception of functional capacity = QOL.	• All groups showed significant improvements in 6MWT, SRT, and WHODAS 2.0. • Only ExpG demonstrated significant improvement on gait speed performed in 10MWT. • Functional trainingG and ExpG improved the perception of quality of life and no groups decreased body mass index significantly. • Only ExpG(G) and ExpG obtained a significant difference in reducing abdominal circumference. • No significant differences were found among the 3 groups in any outcomes.	Non-significant result between groups on 6MWT. *Functional outcome and MET measures; Need a control of cardiac performance during all proposed interventions; Needs to study the effects of different modalities of exercise programs; Need more patients.*
Cikajlo et al. (2019) Slovenia	• Total n. = 20. • Age ExpG (yr) = 67.6 (SD 7.6). • Gender ExpG = 5M, 5F. • Pathology = PD.	**Individual, supervised, outpatient** • ExpG = 3D visualization hand movement training with a pick and place task in the virtual world requiring manipulate virtual cubes (30 min PT, 10 session within 3 wk). • CtrlG = 2D visualization (on LCD) hand movement training with a pick and place task in the virtual world requiring manipulate virtual cubes (30 min PT, 10 session within 3 wk).	• Kinematics hand-temporal and spatial parameters= **TNTSE, ATsM, TNsT, IB, ATI, BBT, UPDRS.** • Motivation = **IMI.** • Upper limb motor function = UPDRS, BBT.	• Substantial differences between the first and the last session for each group. The differences were statistically significant for ATsM, IB and ATI. • Significant differences between the first and the last session for the "perceived competences" measure scale (IMI). The ExpG increase in effort/importance and the CtrlG improved in pressure/tension in the last session.	BBT and UPDRS not statistically significant between the groups before and after. The immersive 3D equipment (glasses) may not be appropriate for every person with PD. *Need more patients and need to increase compliance.*
Shih et al. (2016) Taiwan	• Total n. = 20. • Age ExpG (yr) = 67.3 (SD 9.96). • Gender ExpG = 9M, 1F. • Pathology = PD.	**Individual, supervised, outpatient** • ExpG = balance-based exergaming intervention including reaching activities, weight-shifting activities and marching activities, with progressively increasing level of difficulty (30 min PT, 2/wk x 8 wk). • CtrlG = conventional balance training session including reaching activities, weight-shifting activities and marching activities, with progressively increasing level of difficulty (30 min PT, 2/wk x 8 wk).	• Postural stability = **LOS, OLS (CoP).** • Functional balance = **BBS, TUG**.	• Functional balance (BBS and TUG) improved significantly in both groups post-training compared with pre-training. • ExpG significantly improved LOS performance and OLS on the less affected leg in the eyes-closed condition. • ExpG compared with CtrlG exhibited better performance in directional control of LOS post-training.	Conventional balance training did not reach the minimal detectable change in patients with PD. Results not generalizable. *Need more patients; Reduce possible error in data normalization due to calibration variability during session preparation; Revise patient selection (include others who have a more marked level of deficit, or a non-high baseline level of performance).*

(segue)

Tabella I. *(segue)*

Study	Participants	Intervention	Outcome measures Primary / Secondary	Key results ExpG	Unattained goals / Drawbacks *Hints for future investigations*
Gandolfi et al. (2017) Italy	• Total n. = 76. • Age ExpG (yr) = 67.45 ± 10.7-181. • Gender ExpG = 29M, 19F. • Pathology = PD.	**Individual, supervised, home with skype telerehabilitation** • ExpG = in-home VR-based gravity balance training with the Nintendo Wii Fit system (Telerehb) (30 min PT, 3/wk x 7 wk) • CtrlG = in-clinic sensory integration balance training (SIBT) (30 min PT, 3/wk x 7 wk).	• Postural control = **BBS**. • Perceived level of balance confidence in ADL = ABC. • Gait = 10MWT, DGI. • QoL = PDQ-8.	• Significant between-group difference found only for BBS scores. • Both groups showed an overall significant improvement at the end of treatment and at 1m f-up, as measured on the ABC, 10-MWT, DGI, and PDQ-8. • No statistical significant difference in satisfaction rates.	No measures of muscle strength and body mass; Results not generalizable if pts with cognitive deficits; *Consider the effects of training regarding biomechanical constraints that can affect balance such as muscle strength and lean body mass.*
Mugler et al. (2019) USA	• Total n. = 11. • Age ExpG (yr) = 58.5 (52.19-61 = 69 (SD 7.2). • Gender ExpG = 10M, 1F. • Pathology = Stroke.	**Individual, outpatient** • ExpG = 3 muscle pairs isometric MyoCI training session (60 or 90 min PT, 1/wk x 6 wk). • CtrlG = 3 muscle pairs movement-based MyoCI training without arm restraint (90 min PT, 1/wk x 6 wk).	• Upper limb motor function = **FMA-UE at 6w,** WMFT. • Spasticity = MAS. • Elbow range-of-motion at weeks 6 and 10 = ROM. • Amount and quality of home-based function = MAL-30.	• MyoCI training of 3 muscle pairs significantly reduced impairment (FMA-UE) from baseline to week 6 in each group, and gains persisted at 1 month after training stopped. • No significant differences between groups. • Participants' lab-based and home-based function also improved at weeks 6. • Spasticity also decreased over all subjects and elbow range-of-motion improved. Both moderately and severely impaired patients showed significant improvement.	No effects of stroke type and mixed effects of stroke location on outcomes because of limited lesion localisation; No differences between groups. *Need more patients;* *Consider the patient's active control over the game mode;* *Consider the use of wearable device.*
Lee et al. (2018) South Korea	• Total n. = 30. • Age ExpG (yr) = 63.80 (SD 6.80). • Gender ExpG = 9M, 6F. • Pathology = Stroke.	**Individual, supervised, outpatient** • ExpG = three sessions of game-based virtual reality canoe paddling training (30 min PT, 3/wk x 5 wk) + conventional physical and occupational rehabilitation program aimed at improving balance, lower limb strength and ADL (30 min PT, 10/wk x 5 wk). • CtrlG = conventional physical and occupational rehabilitation program aimed at improving balance, lower limb strength and ADL (30 min PT, 10/wk x 5 wk).	• Postural balance = **mBRT** and **postural sway test** (CoP, PL, SV). • Upper limb motor function = **MBT**.	• Postural balance and upper extremity function showed significant improvements in both groups when compared with the baseline (only mBRT and SV in CtrlG). • The experimental group showed significantly more improvement than the control group in mBRT, SV, and MBT.	No control over the intensity of conventional rehabilitation training; No placebo in CtrlG. *Assessors blinding study design;* *Quantify the intensity of traditional rehab program;* *Include a comparison between task-oriented training and VR training;* *Include long term F-up.*
Rowe et al. (2017) California	• Total n. = 30. • Age ExpG (yr) = 56 (SD 11). • Gender ExpG = 9M, 6F. • Pathology = Stroke.	**Individual, robot assistance, outpatient** • ExpG = high assistance finger training while controlling the number, amplitude, and exerted effort of training movements (60 min PT, 3/wk x 3 wk). • CtrlG = low assistance finger training while controlling the number, amplitude, and exerted effort of training movements (60 min PT, 3/wk x 3 wk).	• Motor function = **BBT at 1m,** FMA, Lateral Pinch Strength, 9HPT, NHSS. • Motivation, self-efficacy, and depression = IMI, BDI, GDS. • Finger proprioception.	• BBT and FMA improved significantly over time. • There was no effect of group for any outcome measure. • Group effects became significant when examined as a function of time for the FMA and the Lateral Pinch Strength Test. • Motivation was significantly higher for participants in the high-assistance group.	Finger proprioception did not vary significantly; Higher level of robotic assistance could reduce patient's attention; High percentage of haemorrhagic stroke survivors among participants; Small benefits of assisted grip; No task-specific training associated; Patient's attention not considered; Evidence of only small differences, and only in FMA, pinch, and in secondary endpoints. *Promote the spontaneous use of the impaired limb with the robot;* *Analyse the effects of attention.*
Tollár et al. (2018) Netherlands	• Total n. = 74. • Age ExpG (yr) = 70.0 (SD 4.69). • Gender ExpG = 15M, 18F. • Pathology = PD.	**Small group (4-6), supervised, outpatient** • ExpG = agility exergaming (EXE) (60 min PT, 5/wk x 5 wk). • CtrlG1 = stationary cycling (CYC) exercise training in a "spinning class." (60 min PT, 5/wk x 5 wk). • CtrlG2 = habitual activity.	• Patients' mobility and clinical symptoms = **UPDRS-II**. • Life domains, QoL = SF-ADL; EQ-5D, PDQ-39, BDI. • Gait and balance = TAT. • Balance control = BESTest. • Fall risk = BBS test. • Gait adaptability = DGI. • Walking capacity = 6MWT. • Postural stability = standing posturography (CoP).	• After treatment, UPDRS-II scores improved but changes did not differ between ExpG and CtrlG1 but differ respect CtrlG2. • BESTest, TAT, the Dynamic Gait Index, EQ5D cum, 6MWT PDQ mobility and 8 out of 9 posturography measures improved in ExpG and CtrlG1 similarly with no change between ExpG and CtrlG1. • depression was reduce similarly in ExpG and CtrlG1. • ExpG resulted better than CtrlG1 in improved SF-ADL, BBS and 2 measures of posturography. • BESTest, TAT, the Dynamic Gait Index, and 4 out of 6 posturography measures did not change.	Motor and non-motor symptoms improved regardless of the exercise stimulus; Short duration, hospital setting only. *Promote longer duration of trial;* *Introduce home-based exercises;* *Consider the executive function as a moderator of mobility improvement;* *Consider neural, biomechanical, or behavioural markers to determine whether EXE and CYC affect mobility and clinical effects through different mechanisms.*
Ghosh et al. (2018) Israel	• Total n. = 47. • Age ExpG (yr) = 58.7 (SD 9.3). • Gender ExpG = 11M, 12F. • Pathology = Stroke.	**Small group (6-8), supervised, outpatient** • ExpG = five video-game consoles alternately: Microsoft Xbox Kinect, Sony Play- Station 2 Eyetoy, Sony PlayStation 3 MOVE, Nintendo Wii Fit and the SeeMe VR system (60 min PT, 2/wk x 12 wk). • CtrlG = Fitness and Mobility Exercise Program, the Graded Repetitive Arm Supplementary Program and the task-oriented intervention (upper and lower extremity movements, stretching, marching and arm swings, walking, functional activities such as picking up and transferring objects) (60 min PT, 2/wk x 12 wk).	• Feasibility = **compliance** (sessions attended/out - percentage attended out of 25 sessions), satisfaction level (questionnaire) and **adverse effects** (monitoring). • Efficacy: **Gait speed, Grip strength = 10MWT, Jamar Dynamometer** (kundis, kg). • Physical activity = steps/day. • Functional ability of the upper extremity = MAT.	• High treatment compliance for both interventions, but satisfaction rated higher for the ExpG. • Significant within-subject effects found for gait speed, demonstrating an improvement for both groups between pre to post evaluations, not maintained at 3m follow-up. • Significant improvement for both groups in grip strength of the weaker and stronger hand between pre to post and pre to 3m follow-up measurements. • There was no significant change in secondary outcome measures (Daily steps and functional ability of the weaker hand did not increase in either group).	Heterogeneous control group. *Include more walking in the training;* *Expressly information, such as perceived exertion, should be added;* *Consider the role of the caregiver for group video exergaming.*

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Tabella I. *(segue)*

Study	Participants	Intervention	Outcome measures Primary / Secondary	Key results ExpG	Unattained goals / Drawbacks *Hints for future investigations*
Lupo et al. (2018) Italy	• Total n. = 16. • Age ExpG (yr) = 52.56 (SD 13.92) • Gender ExpG = 6M, 3F. • Pathology = Stroke.	**Individual, supervised, outpatient** • ExpG = Balance training with biofeedback and simulate ADL (10 min PT, 3/wk, 10 sessions). • CtrlG = Conventional balance rehabilitation training for the recovery of ambigendoness in ADL based on the use of stable sur- faces (i.e. steps) and unstable ones (i.e. oscillating tables and balls of different sizes.) (30 min PT, 5/wk, 10 sessions).	• Balance = **BBS, Stabilometric parameters** (CoP-OE , CE) • Mobility = **RMI.** • Global disability = BI • Severity of the stroke = **NIHSS, CNS** • Compliance = **PRPI.**	• The ExpG group showed a significant improvement in balance skills compared with the CtrlG group (BBS) even after 30 days from EI. • Significant regression of signs and symptoms (NIHSS) was observed in ExpG versus the CtrlG. • Stabilometric tests showed a significant reduction of COP trajectory in both the OE (COP-OE) and CE (COP-CE). • Level of participation in the rehabilitation program was greater in the ExpG group.	Small group; No multidimensional assessment with gait and dynamic balance evaluation. *Evaluate efficacy in persons affected by moderate stroke or other pathologies in which balance is impaired, such as cerebellar stroke and/or PD.*
Rahimi et al. (2019) USA	• Total n. = 25. • Age ExpG (yr) = 57.5 (SD 9.04). • Gender ExpG = 7M, 8F. • Pathology = Stroke.	**Individual, supervised, outpatient** • ExpG = Balance cognitive-motor (Dual-Task, DT) exergame-training (CMT) with Wii-fit games in conjunction with cognitive tasks (11 min PT, 20 sessions over 6 wk). • CtrlG = Conventional customized, progressive balance, endurance and strengthening training (50 min PT, 20 sessions over 6 wk).	• Balance control = **LOS-MVL** for volitional balance; **COM position and velocity, COM state stability** for reactive balance during perturbation • Cognitive = **LNS for WM**, attention + processing speed • Dual-task condition = **SPT** and **LOS with LNS** • Clinical balance = BBS, SANVT, TUG, DINVAT, cogTUG, Chair stand test, Balop square test, ABC. • Cognitive-motor exergaming scores = games scores	• Post-intervention, under DT reactive conditions, ExpG improved both motor (MVL, LNS) and cognition, while the CtrlG improved motor alone. • Under DT volitional conditions, motor performance improved only in ExpG. • Significant increase in COM state stability from pre to post- training demonstrated for both groups, without groups differences. • Significant improvement in all clinical balance measures score in pre-post training for both groups. • Significant increase in scores Bubble Balance, TableTilt, Basic Step, and Light Run ExpG only.	Results from the Category Fluency task were not considered during analysis due to the lack of data for some participants; Small group, with light deficit. *Involve individuals in acute and subacute stages of stroke;* *Involve individuals with mild cognitive deficits to examine any effects of the paradigm for cognitive-motor interference.*
Iosa/Morone et al. (2018) Italy	• Total n. = 16. • Age ExpG (yr) = 55.4 (SD 7.7). • Gender ExpG = 9M, 7F. • Pathology = MS.	**Individual, inpatient and outpatient** • ExpG = Serious Games-based upper extremity therapy with Virtual reality, to improve movement coordination, reaction speed and timing, hand-eye coordination and spatial awareness (40 min PT, 4-5/wk, 12 sessions over 6 wk) + usual rehabilitation services. • CtrlG = Exergames training to improve timing, dexterity, hand-eye coordination, perceptual skills and spatial awareness. (40 min PT, 4-5/wk, 12 session over 6 wk).	• Activity level flow and gross arm and shoulder movements = **9HPT, BBT.** • User-experience indicators = EQ-VAS, SF-12.	• ExpG had a clinically and statistically significant increase in velocity of five pinch, grasping and releasing movements of the treated hand as measured by the 9HPT but there was no significant between groups treatment effect for either test. • Only CtrlG had a significant increase in perception of health (EQ-VAS) and significant improvement in the physical domain of the SF-12: mental domain. • Significant between groups treatment effect only in perception of health (EQ-VAS).	Small group; No significant difference between groups; No motivational effect of the serious games. *Test serious games in the home-based setting.*
Thielbar et al. (2020) USA	• Total n. = 20 • Age ExpG (yr) = 59.7 (SD 10.5). • Gender ExpG = 17M, 3F. • Pathology = Stroke.	**Multiple or individual, home-based** • ExpG = First SU: home-based single-user (SU) VR upper extremity therapy (50 min PT, 4/wk x 2 wk) + MU mode (60 min PT, 4/wk x 2 subsequent wk) -> 16 session over 4 wk. • CtrlG = First MU: home-based multiuser virtual reality (VR) upper extremity therapy (MT) (60 min PT, 4/wk x 2 wk) + SU mode (60 min PT, 4/wk x 2 subsequent wk) -> 16 session over 4 wk.	• Calculated **Total Arm displacement** • **Session duration** • Upper limb functions= FMA-UE • Time spent using each MU and SU • Compliance = IMI	• Arm displacement during a session was significantly affected the mode of therapy. • Whole arm displacement was seen in both groups, the First MU group tended to produce more than the First SU group. • Compliance was very high (99% compliance for MU mode and 89% for SU mode). • Participants spent significantly more time training in the MU mode than in the SU mode. • Participants in the First MU group generally had longer sessions; no significant. • FMA-UE score improved significantly in both groups. • Scores for the IMI rated higher for the MU mode than the SU mode, but no statistically significant differences were present between groups.	Participants' use of a standard screen may have adversely affected the results; No long term F/U; Finger movement not monitored. *Add finger exercises and hand gripping activities;* *Use 3D monitors/televisions to enhance interaction;* *Evaluate effects of e-motivation (IMI3) 2 scale).*
Song et al. (2018) Australia	• Total n. = 60 • Age ExpG (yr) = 68 (SD 7) • Gender ExpG = 15M, 16F • Pathology = PD	**Individual, initially supervised then alone, home-based** • ExpG = step, balance, cognitive load VR open-source Dance Revolution "Stepmania" game (15 min, 3/wk x 12 wk) + usual healthcare. • CtrlG = no intervention, usual healthcare.	• Stepping performance= **choice stepping reaction time Test** • Gait= **FGA** • Phys. capacity= measures, = falls, self-report mobility and balance: Hip abductor muscle power, TUG, MCA, TMT A-B, NYGa, FESIq.	• No differences between ExpG and CtrlG in primary or secondary outcomes except for the Timed Up and Go test, lower in the control group). • ExpG perceived improved mobility, decrement in TUG. • Interaction effects seemingly positive effects for the low-severity group. • Remotely supervised ExpG in mid-mod PD is feasible (high compliance 86%), has differential impact by severity of disease.	Small group (high functioning people); No overall short-term positive effects on physical and cognitive function; No F/U; Insufficient amount of practice; UG adequate to the severity of disease? *Investigate the influence of training dose and disease severity;* *Determine if greater supervision and personalization of the intervention would be more effective than minimal supervision;* *Assess long-term effect.*
Park et al. (2017) South Korea	• Total n. = 10. • Age ExpG (yr) = 62.60 ± 12.14. • Gender ExpG = 6M, 4F. • Pathology = Stroke.	**Individual, supervised (+safety harness), inpatient** • ExpG = Xbox Kinect (30 min, 7/wk, 6-wk) + 60 min of conventional PRT. • CtrlG = Conventional strengthening, functional, balance and gait training PRT (30 min, 7/wk x 6 wk).	• Lower limb motor recovery= **FMA** • Balance= BBS • Gait= TUG, 10mWT	• Scores on FMA-LE, BBS, TUG, and 10mWT improved significantly in both groups. • The pre-to-post difference scores on BBS, TUG, and 10mWT for the ExpG were significantly more improved compared with CtrlG. • VR training improves motor function.	Different training dose in the two groups; Participants were patients at first stroke and w/o cognitive deficit; Possible error in feedback of Kinect due to the limitations of the sensor to differentiate the participant from the therapist providing assistance. *Correct the above limitations.*

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Tabella I. *(segue)*

Study	Participants	Intervention	Outcome measures **Primary** / Secondary	Key results ExpG	Unattained goals / Drawbacks ***Hints for future investigations***
Rikos et al (2017) Brasil	• Total n. = 20. • Age ExpG (yr) = 61.70 ± 6.83. • Gender ExpG = 6M 6F. • Pathology = PD.	**Individual, supervised, outpatient** • ExpG = Nintendo Wii Balance Board (30 min, 2/wk x 12 wk). • CtrlG =conventional exercise program (30 min, 2/wk x 12 wk: 10 min warming, stretching and active exercises; 10 min resistance exercises for the limbs; 10 min diagonal exercises for the trunk, neck and limbs).	• Balance= **BBS** • Fatigue= FSS-BR • Exercise capacity= 6MWT • QoL= PDQ39	• ExpG showed significant balance and fatigue improvement at 12w, not sustained at 60-day follow up.	Small group; No recording of the number of falls before and after intervention; No measures regarding safety and playing ability. *Find ways to reduce the risk of falling for patients who conduct training at home or who need direct supervision from a qualified professional*
Ngernthuai et al (2017) Indonesia	• Total n. = 19. • Age ExpG (yr) = 58 (48-65). • Gender ExpG = 7M, 2F. • Pathology = stroke.	**Individual, self-administrated (1/w control), home-based** • ExpG = Arm and hand exergame program with a technology-supported system: SCRIPT (dynamic wrist and hand orthosis (30 min, 6/wk x 8 wk). • CtrlG = conventional home exercise programme with arm and hand training (30 min, 6/wk x 8 wk).	• User acceptance= **training duration** • Arm and hand function= **FMA, Grip strenght, BMI, AAAT, BBT** • QoL= SIS.	• Averaged weekly training duration higher in CtrlG. • Perceived motivation positive and equal in both groups. • Both groups showed moderate improvements on most clinical outcomes with no differences between groups. • Changes in Box and Block Test correlated positively with training duration. • Training duration strongly and positively correlated with training-induced changes in the Box and Block Test.	Small groups; Different M/F distribution between groups; Different number of available exercise between groups; Neither the assessor nor the patients were blinded; Errors or overestimation by patients in recall of exercise time. *Find ways to improve adherence. Optimization of technology, and regular contact between patients and a professional*
Allen et al (2017) Australia	• Total n. = 36. • Age ExpG (yr) = 67.5 ± 7.3. • Gender ExpG = 12 M, 7F. • Pathology = PD.	**Individual, initially supervised, home-based** • ExpG = Arm and hand coordination exergame under single and dual cognitive task conditions with Unity game development software (3/wk x 12 wk). Approximately 15 minutes of actual training duration. • CtrlG = no intervention but usual care and activities.	• Upper limb performance= **9HPT** • Upper limb speed and accuracy= Tapping test and error • Upper limb dexterity= Coin rotation task, BBT, hand RT • UE perception ability= MAM and global perceived effect scale • Cognition= MCA, TMT-A, -B. • QoL= PDQ39.	• No between group differences primary or in any secondary outcome measures except for the tapping test (speed score under single task condition). • ExpG increase speed but also error in tapping test (demonstrated in accuracy under both single and dual cognitive task conditions). • ExpG did not perceive any overall improvement. • ExpG showed a significant trend towards improvement in TMT-A.	Cognitively intact patients, mild to moderate PD severity; Short-term study; No variety of games; *Consider the specificity effect of task practice, long term adherence, and greater variety in games;* *Explore the interaction between cognitive aspects and motor recovery of the upper limb.*
Şahin et al (2018) Turkey	• Total n. = 42. • Age ExpG (yr) = 54.15 ± 20.29. • Gender ExpG = 15 M, 6F. • Pathology = stroke.	• Individual, supervised, inpatient. • ExpG = Nintendo Wii-based balance and upper extremity training (45-60 min, 3/wk x 10 wk). • CtrlG = Bobath neurodevelopmental treatment (NDT) with upper extremity activities, strength, balance gait and functional training (45-60 min, 3/wk x 10 wk).	• ADL= **FIM** • QoL= **NHP**	• Both groups improved significantly in FIM and NHP with no between group differences. • ExpG was more satisfied.	No without treatment-control group; no FU; Limited number of games; No BMI measurement; The choice with respect to outcome measures was inadequate; There was a continuing need for the therapist's guidance to correct the patient's compensatory mechanisms and movements. *Consider a combined treatment group, double-blind controlled study;* *Increase the variety of games and study their influences on patients.*
Lee et al. (2017) Taiwan	• Total n. = 47. • Age ExpG (yr) = 59.35 ± 8.05. • Gender ExpG = 19 M, 10F. • Pathology = stroke.	**Individual, supervised, outpatient** • ExpG = Microsoft Kinect function for Xbox training with interactive VR balance-related games (45 min, 2/wk x 6 wk) + 45 min standard treatment rehabilitative protocol. • CtrlG = ST rehabilitative protocol (90 min: 45 min strengthening, endurance, ambulation, and ADL training + 15 min of warm-up exercises + 30 min of functional balance exercises, 2/wk x 6 wk).	• Balance= **BBS**, FIT, cogTUG. • ADL= MBI • Balance confidence= ABC • QoL= SIS.	• Both groups shows significant improvement in BBS and cogTUG from pre to post and at 3mFU (EXP has improved the most). • No significant difference in other outcome measures within or between groups.	Traditional treatment was constant; No strict control over the specific tasks performed during routine therapy. *Higher rehabilitation doses and frequencies to be use.*
Ulkar Karaca et al. (2018) Turkey	• Total n. = 23. • Age ExpG (yr) = 62.3 ± 11.79. • Gender ExpG = 5 M, 7F. • Pathology = stroke.	**Individual, inpatient** • ExpG = Nintendo Wii-based balance rehabilitation (20 min, 5/wk x 4 wk) + conventional balance rehabilitation exercises with PT, OT and cognitive therapy. • CtrlG = conventional balance rehabilitation exercises (1- 1 h x day, 5 days x week x 4 wk).	• Balance= **BBS; TUG, FIT, PASS, SBI** • Postural sway (COP) • FMA and FIM	• Both groups improve significantly or in all the measures except COP, ExpG showed greater improvement than CtrlG. • Significant improvements in BBS and FRT, TUG test scores was not significant. • PASS significant improve in both groups, no difference between groups. • Wii Fit-based balance rehabilitation plus traditional treatment improves static and dynamic balance, functional motor ability, and independence.	Short follow-up period; Small groups; Both subacute and chronic stroke patients included. *Study the effect of the Wii Balance Board in improving dynamic balance.*

Mean size of the experimental group (ExpGr) was overall sixteen subjects, with 4% females. As for age, in two studies (7,27), the age range in ExpGr was very broad (27-78 years), while it was just below the age limit of 55 in another study (28). We kept these last studies in the review due to important contribution to knowledge.

In the studies considered, the criteria for inclusion of patients in the study samples were based on disease type, severity and duration, motor or cognitive potential, and sometimes age. Exclusion was determined by the presence of cognitive / sensory deficits, aphasia, low vision, motor problems or syndromes incompatible with training. In some cases, the patient's need of use of assistive devices or previous experience with EG determined retrospective exclusion as a participant.

EG and VR

In fifteen articles the concepts of VR and EG were used interchangeably, since VR was meant as stylistic component of EG (i.e. exercise by gaming through virtual environments, virtual objects or players). Instead in three articles (9,11,30), the authors specifically differentiated between EG (commercial games, more convenient and easy to use), and VR (specific for rehabilitation). In six articles (25%) the term "virtual reality" does not appear.

Type of treatment and duration

The training was provided on an outpatient (50%) or inpatient (16%) basis, or at home (33%) (Table I). EG-VR training was delivered as a stand alone treatment (71%), or it was in addition to traditional treatment (29%). The experimental treatment lasted on average 630 minutes over 6 weeks, with a follow-up (in 10 studies only) at 2.7 months after treatment. Primary outcomes included balance and gait (54%), upper limb functionality (41%), and physical activity (4%).

Type of platforms and sensor devices

The technological platform observed in the included studies were:

– (29%): Nintendo Wii Fit with balance board (23,29-31), Nintendo with Wiimote (32) and Nintendo Wii Sports with a paddle integrated sensor (3);
– (41%): Kinect (28,34-36), Xbox Kinect (6,7,26,37), and Kinect2Sctratch (11);
– (30%): Other platforms: Stepmania used with a special mat (8), and Script with special dynamic orthosis for UE (39).

Rehabilitation specific designed platforms were:

– Unity Game Development software (40), Rehab@home (9), and Riablo (24);
– myoelectric computer interface Phython used with a cursor (27);
– MotionRehab AVE (41);
– 3D Oculus with head mounted device (42);
– a finger robotic exoskeleton in the form of a special glove (25).

As a theoretical reference, Hebbian's theory of plasticity (25) and Gentile's theory of motor learning (37) were mentioned in two studies, while neurobiological theory was implicitly assumed in a study related to balance training (24).

Safety and feasibility of exergaming

In some studies, patient's safety aspects were considered by verifying a posteriori the absence of adverse events occurring during training with EG (28,30), or by recording the number of accidental falls during the same period (23) or during the following six months (38) (Table II).

In some cases, the patients' subjective perceptions of pain, fatigue or discomfort arising during exercise were considered as a safety criterion to immediately end the training session (32).

Some studies observed specific risks associated with carrying out the exercises: risk of repetitive injury, with patients complaining of upper extremity soreness after a 30-minute Kinect2Scratch games intervention (11), and shoulder pain due to the use of hemiparetic side (33).

Increased pressure/tension score and corresponding higher level of average tremor was observed in PD patients engaged in 3D vs. 2D VR manipulation tasks (42).

One study adopted preventive measures (a harness safety belt) to minimize risk for stroke patients performing standing activities (6).

Home based training has been shown to be feasible (9,26,38-40) even in innovative ways (e.g. Myoelectric computer interface training) (27), though safety in the home setting could be a problem for patients with cognitive decline (23). Direct supervision by a physical or occupational therapist was almost always required to set and regulate the type and progression of exercises, to assist or encourage the patient, and ultimately to administer assessment tests. Otherwise, there were regular home visits by the researcher (25,36,38,39) or contact via skype during the sessions (23).

Patient perceptions

Patient motivation and compliance were generally high (6,7,24,25,26,30,36,38), with an explicit greater appreciation of technological training than traditional rehabilitation (36,40). Satisfaction and motivation were assessed by questionnaires at follow-up or at each training session, often using the Intrinsic Motivation Inventory (25,36,39,42), or including quality of life assessment (23,26,31,32,34,37,39,40). In case of non-evaluation of users' perceptions, this has been addressed as a specific limit of the study (9,28). Patients reported that adherence to the program was strengthened by a wide variety of exercises available and regular contact with the referral therapist (39,40).

Problems detected with patients using technological equipment

The possibility of a Kinect sensor error in distinguishing the assistant from the participant during some phases of the assisted movement has been reported (6). Space problems with equipment have been reported in relation to the home setting (40). The participants' lack of experience with technology did not reduce participation in training (36). Eye fatigue could arise in PD patients who

Table II. *Main conclusions of articles based on: the used platform, significant intra/inter group effects, participants' experience, and adverse events encountered* (see common legend)

VG platform	Brief description /name of game	Use of external device	Significant effects (intra/inter group) analysed and identified							Participants' experience	Adverse Events (AE)	Reference (study)
			Upper Limb	Lower Limb	Balance	Physical Activity	Cognition/executive functions/ADL, mobility	Gait	Spasticity			
Kinect	Motion Rehab AVE	RGB video detection camera; a depth range sensor; an infrared sensor	**√ intra and inter group (not wrist and hand)**	–	**√ intra group**	–	–	–	–	Not assessed	Not assessed	Henrique et al. (2018) Brazil
Kinect Rehab system	Choice of five UE activities performed against gravity	Camera and desktop computer, clinical website	**X No**	–	–	–	**√ intra and inter group**	–	–	Four patients withdrew (3 in ExpG) for lack of time, general fatigue, and loss of motivation. Choice of EG based on patient's abilities, interests, motivation, and fatigue. High adherence rate.	No serious AE reported in ExpG. One case of dizziness	Dhiviliyan et al. (2019) Canada
Kinect2Scratch	Scratch 2 (), TIDeR checklist, AxIO3D-X software	Triaxial AccGraphGT3X+ activitemonitors	**√ intra group**	–	–	–	–	–	–	Participation measured by PARTI and accelerometry resulted higher in the ExpG than in the CntG	Not serious AE reported. Most participants in the CntG completed all UE sessions after training, subjoined spontaneously.	Hung et al. (2019) Taiwan
Xbox Kinect 360	Kinect Adventures game	–	–	–	–	–	–	**√ intra group**	–	ExpG improved Quic (FDG):39 and EQ-120) All groups improved in activity and participation (WHODAS 2.0), 60%	Not assessed	Ferraz et al. (2018) Brazil
Unity3D software, Oculus Rift CV1, or laptop	3dCubes exergaming system	Small size glasses; 4D camera (Leap Motion Controller); 2D or 3D feedback displays	**√ intra group**	–	–	–	–	–	–	ExpG was more motivated (increased enjoyment/interest at WM)	Not reported but patients could experience visual discomfort, fatigue or even transient myopia	Cikajlo et al. (2018) Slovenia
Microsoft Kinect	Reaching task 1, Reaching task 2, Obstacle avoidance, Marching	Kinect sensor	–	–	**√ intra group**	–	–	–	–	Not assessed	Not reported	Shih et a. (2016) Taiwan
Nintendo Wii	Wii Fit gaming system	Balance board	–	–	**√ inter group**	–	**√ intra group**	**√ intra group**	–	Satisfaction questionnaire or SmFU showed no differences between groups. Logbook to record feelings, difficulties or AE	Not reported	Gandolfi et al. (2017) Italy
Myoelectric computer interface (MyoCI)	Target game for arm	Wireless, active EMG electrodes Padded wrist and hand splint fixed to the armrest of a chair. Curved	**√ intra group**	–	–	–	**√ intra group**	–	**√ intra group**	Use of technology was well tolerated	Not reported 1 patient excluded for nausea.	Mugler et al. (2019) USA
Nintendo Wii	Nintendo Wii Sports Canoe Paddling Training	Safety belt on their waist during the training, motion controller, canoe paddle accessory, Grip-assist gloves, springboard Balance Board	**√ intra and inter group**	–	**√ intra and inter group**	–	–	–	–	Not assessed	Shoulder pain due to increase use of the upper extremity	Lee et al. (2018) South Korea

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Tabella II. *(segue)*

EG platform	Brief description /name of game	Use of external device	Significant effects (intra/inter group) analysed and identified							Participants' experience	Adverse Events (AE)	Reference study
			Upper Limb	Lower Limb	Balance	Physical Activity	Cognition/executive functions/ADL, mobility	Gait	Spasticity			
FINGER robotic exoskeleton	Guitar Hero	FINGER robot	**√ intra and inter group**	–	–	–	–	–	–	Both groups improved in motivation (IMI; better in ExpG), self-efficacy, and depression	Not assessed	Rowe et al. (2017) [28][Bertoz]
X Box Kinect 360	Kinect Adventures video game	Rider watches strapped to the chest	–	–	**√ intra group**	**√ intra group**	**√ inter group**	**√ intra group**	–	100% adherence, 0% dropout rate	Not reported	Tuffaz et al. (2018) [Bertoz]
3 of 5 following alternately: Xbox Kinect, Sony PS-3, Eyetoy, Sony PS-3, MOVE, Nintendo Wii Fit, Sawtila VR system	Wii fit, walking/jogging game, other games played in pairs	Consoles equipment	**√ intra group (grip strenght)**	–	–	**X No**	–	**√ intra group**	–	High treatment compliance for both ExpG (78%) and ConG (667%), but satisfaction was rated higher for the ExpG (93%) than the ConG (71%)	Not reported	Gioia et al. (2018) [Lopez]
The KURULI™	Exercise to simulate ADL	Inertial motion sensors, elastic bands placed on the chest and leg, force platform and FG based feedback	–	–	**√ inter group**	**X No**	–	–	–	Level of participation in the rehabilitation program was greater in the ExpG group	Not assessed	Lopez et al. (2018) Italy
Nintendo Wii	Four Wii fit games (Bubble Balance, Table Tilt, Tight-Rope Walking, Soccer Head, Basic Run or basic step)	Eight-camera motion capture, 26 reflective markers placed on the body joints; balance board; Thera-Bands in ConG	–	–	**√ intra group**	–	**√ inter group**	–	–	Not assessed	Not assessed	Kannan et al. (2019) USA
Kinect / (ConG: Nintendo Wii Console)	ReHab@Home: six arm rehab games in virtual space w purposeful movements in home and garden environments/ (ConG: commercial EG requiring arm movements)	Camera and a depth sensor/ (ConG: controller)	**√ intra group**	–	–	–	–	–	–	Serious games were perceived positively w terms of user experience, satisfaction and motivation	Not reported	Gerardelli et al. (2018) Italy
Kinect	VERGE system (MU virtual reality system), 2 different virtual environments: Ball Bump, Trajectory Trace, and Road Fight exercises	Wireless mouse	**√ intra group**	–	–	–	–	–	–	Patients spent significantly more time training in the MU mode than in the SU mode. IMI scores rated higher for the MU mode than the SU mode, but no significant differences between groups.	Not assessed	Thielbar et al. (2020) USA
VR open-source Dance Revolution	Dance Revolution "Stepmania" game, modified version	Custom-made step Mat, six arrows as well and two central stance panels, small computer	–	**X No**	**X no**	**X no** (except in TUG: Better in ConG)	**√ inter group**	**X no**	–	Reported perception of mobility &balance, high adherence, not effective in improving the outcomes	One participant reported a non-injurious fall. Witnessed by self-report log book	Song et al. (2018) Australia
Xbox Kinect	Kinect Sports Pack and the Kinect Sports Pack 2	Kinect sensor and console sensor infrared camera, harness mounted to the ceiling for safety	–	**√ intra group only**	**√ inter and intra group**	–	–	**√ inter and intra group**	–	High level of compliance, more in ExpG	Not reported	Park et al. (2017) South Korea

(segue)

Tabella II. *(segue)*

VG platform	Brief description /name of game	Use of external device	Significant effects (intra/inter group) analysed and identified							Participants' experience	Adverse Events (AE)	Reference study
			Upper Limb	Lower Limb	Balance	Physical Activity	Cognition/executive functions/ADL, mobility	Gait	Spasticity			
Nintendo Wii	Seven Wii Fit games.	Balance Board.	-	-	**√ intra group, not at FU**	-	-	-	-	No significant improvement in the QoL domains was reported.	Not reported.	Ribas et al. (2017) Brazil
SCRIPT exercises	Gaming exercises, controlled by arm and hand movements.	SCRIPT dynamic wrist and hand orthosis with sensors, the SaeboMAS and a computer with touchscreen.	**√ intra group**	-	-	-	-	-	-	Self-reported frequency and duration of training in a diary; motivation (IMI). Weekly home visits were highly appreciated by both groups.	Not assessed.	Nijenhuis et al. (2017) Netherlands
Unity game development software (specifically developed)	Two coordination VG (Marshmallow game and Chicken game) under six different conditions.	Table-top mat, keyboard and tablet.	**√ intra group only in one outcome (tapping speed).**	-	-	-	**√ intra group**	-	-	97% of adherence monitored through participant log books. At 12w questionnaire: 68.8% enjoyed the games; 68.8% found the system easy to use; 43.8% would continue. All participants improved in their ability to play the games. Patients would have preferred more variety in the games provided.	Not reported. Monitored through participant log books. One participant reported an exacerbation of a previously existing chronic pain condition and withdrew (unclear if this was related to trial participation).	Allen et al. (2017) Australia
Nintendo Wii	Five games selected from the Wii sports and Wii Fit packages for upper limbs (tennis and punch out) and balance training (sightseeing (mission, tilt table and heading), respectively.	Balance board, Wii remote control and "nunchucks" equipment.	-	-	-	-	**√ intra group**	-	-	Treatment satisfaction assessed using VAS. Exp6 was better satisfied from the therapy.	Not reported.	Şimşek et al. (2016) Turkey
Microsoft Kinect Xbox	Nine games selected from the Kinect Sports, Kinect Adventures, and Your Shape Fitness Evolved packages.	Televisions, handrail placed in front of the participant if required for safety.	-	-	**√ intra group**	-	**X No**	-	-	The pleasure scale and AE were recorded after each training session. Experience was more pleasurable in Exp6 (Feasibility: 44 PACS).	Exp6 reported 19 AE (soreness of the upper limbs in 6, muscle hypertonicity in 5, dizziness in 6, and leg pain in 2). Ctrl2 reported 30 AE (soreness of the lower limbs in 10 and upper limbs in 5, muscle hypertonicity in 7, dizziness in 2, shoulder pain in 4, and lower back pain in 2). No serious AE reported.	Lee et al. (2017) Taiwan
Nintendo Wii	Wii Fit	Balance Board; iBAT 3000 balance platform)	-	-	**√ intra and inter group**	-	-	-	-	Exp6 enjoying the sessions.	Not assessed.	Ulkar Kanan et al. (2018) Turkey

wear glasses while using immersive 3D equipment (42), and frustration could occur in older adults with cognitive problems (37).

Balance training

Balance training was based on WiiFit games (23,30,31) or dual-task training technique (29), or a combination of upper limb exercises (32) and postural and locomotor skills (34,35), or focusing on physical conditioning and muscle-strengthening (26,33). The Kinect (33), the Riablo (24) and Stepmania (38) were also used.

The patient mostly maintained an upright position, or sometimes alternating sitting-upright (26), or always sitting (33).

Upper limbs training

Upper limb training was based on gross limb movements (11,27,28,33,40,41) or finger and hand movements (25,33,39,42), including trunk movements (41). The patient maintained the sitting or alternated the sitting / standing position. Biofeedback technique (27) and robotic therapy (39) have also been used. Beside Wii remote (32), particular devices such as gripping assist gloves (33), special force-sensing gloves (25), hand-wrist splint (27), hand orthosis (39), or head-mounted device (42) were sometimes used with particular systems.

Particular techniques

Multi-user therapy (36) and robotic (25) were used for upper limb training, while Dual Task was used for balance training (29). Biofeedback with myoelectric interface was used to reduce spasticity in upper limb muscles (27), and biofeedback associated with IMU sensors and static force platform was used to improve postural and balance skills (24).

Feedback and difficulty level

Almost all EGs included visual-auditory feedback provided to the patient in real time, as a form of encouragement, for correction, or as scoring information. The therapist established the initial difficulty level of exercise, based on the patient's skills and motivation, and adapted it gradually, even at a distance, based on the attained score (39).

In some cases the patient himself decided independently the intensity of the exercise, on the basis of subjective perception (26,41). Rest intervals between activities were sometimes indicated in the protocols (27,32). In one study, patients also had the opportunity to play the video clip of the training sessions, to understand errors and correct performance (32). Wide variability characterized the number of sessions, from a minimum of 6 (27) to over 30 (6,32,38,39,40), as well as the session duration, from a minimum of 15 (29,38,40) to 60-90 minutes (27), with a maximum cumulative training duration of 25-30 hours (43).

Outcome measures

Each study used heterogeneous sets of outcome measures to evaluate rehabilitation. Overall, 54 types of measurement tools appear in the analyzed studies (Table III).

The most used were the Berg Balance Scale, together with instrumental measurements of balance and gait, the Timed Up & Go, and other tests for the upper limbs function (Fugl-Meyer Assessment, Box & Block Test, and Motor Activity Log). Most of outcome measures are generic and performance-based (except Fugl-Meyer, which is stroke-specific, and Motor Activity Log which is self-reporting).

Additional tests, questionnaires, clinician-rated instruments or patient-reported results appear with low frequencies of use (we counted 27 different tools used only once by a single study) to assess general health, quality of life, emotions, fatigue, pain, falls, spasticity, manual and fine dexterity, disability and independence, cognitive aspects, strength, and transfer ability. Pathology-specific measures were addressed to stroke (14 tools), to PD (6 tools) and MS (2 tools). 44% of the outcome measures included indications about MCD (Minimal Detectable Change) or MCID (Minimal Clinically Important Difference) as statistical properties. 66% of the studies provided outcome results that were comparable to the available MCD and MCID reference values.

Instrumental quantification of outcomes

Some studies have used additional instrumental methods to quantify the results: "leap motion controller" for hand movements and tremor (42), kinematic analysis for range of motion during reaching tasks (27), automatic calculation of the finger motions (25), electronic platforms for static and dynamic balance (24,30), the Wii Balance Board integrated system (33), accelerometer and force dynamometer (7).

Other physiological (heart rate), psychophysical (Borg scale) and subjective measures (VAS), or neuropsychological measures were used through the studies.

Effectiveness of EG-VR training

Despite significant improvements in balance achieved through EG-VR, those were not sufficient for patients to achieve independence in activities of daily living (6,37), either this result occurred only in a small sample (30). In other cases, the improvements in balance did not attained the threshold of MDC (35) or MCID (23). Upper limb function (27), fine hand movements (9), and perception of general health (26) improved significantly after training. A greater volume of upper limb activity was achieved compared to traditional therapy (36), however this was not associated with evident functional relapse (39). The benefits obtained from EG-VR training were not maintained at follow-up (6,7,11,27,28), or were maintained but at a short follow-up (30,37). In some cases, patients reported subjectively perceived improvements in ADL performance (36,38), which however did not rule out general aerobic training as a concomitant cause (26).

Discussion

As already highlighted in the literature (19), the studies on the use of EG in rehabilitation don't provide

Table III. *Outcome measures in the studies examined* **(see common legend)**

Outcome measure/ measurement mode	Target	Neurological population to which it refers	Type of measure	Domains	Inclusion in core-set	MCID	MDD	Reference to reviewed papers
BBS (1989)	Balance (static and dynamic)	Neurologic conditions	Performance-based	**Activity.** 14-item clinician-rated scale that assesses sitting and standing, static and dynamic balance (only one item on sitting balance).	CPG APTA (Moore et al. 2018)	4 (di 6-7 cronici ictus); 7 acuti ictus; 5 PD (Mhiere et al. 2018)	11.5 in acute stroke	-(Ekaqbi and Peiseko Pretok 2019; Shih et al. 2016) -(Landolfi et al. 2017) -(Henrique et al. 2018) -(Kannan et al. 2018) -(Karacu, Butur and Karatas 2018) -(Lee et al. 2017) -(Lupo et al. 2018) -(Rilas et al. 2017) -(Tuller, Nagy and Horinbagyi 2018)
Electronic platform/ walkway	Balance, gait	Neurologic conditions	Performance based	**Activity.** Assessment of quality of gait and postural stability.	-	-	-	-(Lee et al. 2017) -(Lupo et al. 2018) -(Kannan et al. 2018) -(Karacu et al. 2018) -(Shih et al. 2016) -(Song et al. 2018) -(Tuller et al. 2016)
FMA (1975)	UE-LE	Stroke specific. Acute and chronic patients post-stroke.	Performance-based impairment index	**Body function/structure.** (5 domains with 155 items). • Motor function (Upper and Lower limbs) • Sensation (touch sensitivity, and joint position sense) • Balance (seated and standing) • Joint range of motion • Joint pain	CPG APTA (Moore et al. 2018)	FMA-UE score in patients with chronic stroke is 6.17, or a 14% change from baseline	Established for UE (6 points), not for LE. For chronic stroke: 3 for severely impaired patients, and 8 to 7 for mildly to moderately impaired patients.	-(Henrique, Ezkurdi and Do Nascim 2019; Norouzi-Gheidari et al. 2019) -(Hung et al. 2019) -(Mughler et al. 2010) -(Rowe et al. 2017) -(Tejerina et al. 2017)
TUG, TUGcog (1991)	Balance	Neurologic conditions	Performance based	**Activity.** It is a test of mobility, balance, and locomotor performance.	StrokeEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce	7.84	Time > 20 secs typically indicates independence in most ADL's and outdoor mobility while 20-29 secs indicates probable need for a gait aid and supervision for outdoor mobility.	-(Ekaqbi and Peiseko Pretok 2019; Shih et al. 2016) -(Lee et al. 2017) -(Kannan et al. 2018) -(Karacu et al. 2018) -(Song et al. 2018)
BBT (1985)	UE	Neurologic conditions	Performance-based	**Activity.** Assesses manual dexterity in terms of number of blocks grasped, transported and released in one minute.	-	5.5 cubes / min (most affected side) and 7.8 cubes/min (least affected side)	-	-(Norouzi-Gheidari et al. 2019) -(Rowe et al. 2017) -(Santostefano et al. 2018) -(Allen et al. 2017)
MAL (2006)	UE	Stroke	Self-report, semi-structured interview to assess arm function	**Activity/Participation.** Amount of the affected hand usage (MAL-AOU) and the quality of movement (MAL-QOM) during 30 daily functional tasks.	No. This tool captures the important element of the patient's perception of arm function. Its inclusion would complement data gathered in a clinically administered, performance-based test.	16.8% (MAL-AOU); 13.4% (MAL-QOM)	1.0-1.1	-(Hung et al. 2019) -(Ngwa Puis et al. 2017) -(Norouzi-Gheidari et al. 2019) -(Mughler et al. 2010)
6MWT (1969)	Walking	Neurologic conditions	Performance based	**Activity.** Measure of gait velocity and endurance	StrokeEDGE consensus panel recommendations (Bushnell et al. 2011)	25 meters for people with acute stroke; 50 meters in neurological patients (Bukannon 2016)	Not reported for stroke. Estimated to be 54-60 meters for patients with COPD.	-(Ferraz et al. 2018) -(Kannan et al. 2018) -(Rilas et al. 2017) -(Tyldie et al. 2019)
10 MWT (2006)	Walking	Neurologic conditions	Performance based	**Activity.** Measure of walking speed (instructions for to walk at a comfortable pace or to walk as quickly as possible)	StrokeEDGE consensus panel recommendations (Bushnell et al. 2011)	0.1 m/s in subjects with stroke	For geriatric population: 0.05m/sec (small meaningful change) and 0.13m/sec (substantial meaningful change). For comfortable gait speed, 0.18 m/s in patients post stroke. For fastest gait speed, 0.25m/sec in PD patients.	-(Ferraz et al. 2018) -(Landolfi et al. 2017) -(Lizano et al. 2016) -(Kannan et al. 2018)
PDQ39 (2016)	Health related Quality of Life	PD	Patient reported outcome	**Functioning.** Impact of PD on specific dimensions of functioning and well-being.	StrokeEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce	Defined	A decrease of at least 5.39 points in the PDQ39	-(Allen et al. 2017) -(Ferraz et al. 2018) -(Rilas et al. 2017) -(Tuller et al. 2016)

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Tabella III. *(segue)*

Outcome measure/ measurement mode	Target	Neurological population to which it refers	Type of measure	Domains	Inclusion in core set	MCD	MCID	Reference to reviewed papers
FRT/ mFRT (1990)	Balance	Neurologic conditions	Performance based	**Body Structure, Function, Activity.**	StrokEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce	Acute stroke: 2.3-2.6 cm (paretic-over paretic side) Subacute stroke 5.7 cm; PD 7.1 cm	-	-(Given et al. 2016) -(Lee et al. 2017) -(Barasa et al. 2018)
Reporting of adverse events	Fatigue, soreness, hypertonicity, dizziness, localized pain, falls	Neurologic conditions	Self-report	**Activity.** Assessment of subjective perception while performing tasks/activities	-	-	-	-(Aller et al. 2017) -(Hung et al. 2019) -(Lee et al. 2017) -(Jung et al. 2018)
Patient's reported outcomes	Amelioration in movement, QoL satisfaction, user experience	Neurologic conditions	Self-report	**Participation.** Opinion on the degree of participation in social and family activities and roles.	-	-	-	-(Given et al. 2016) -(Jonsdottir et al. 2018) -(Nijenhuis et al. 2017) -(Jung et al. 2018)
GDS (1982)	Emotion	Neurologic conditions	Patient reported outcome	**Body Function.** Assess depression and suicide ideation in elderly subjects.	-	-	-	-(Ferraz et al. 2018) -(Given et al. 2016) -(Rowe et al. 2017)
IMI (1982)	Emotion	Neurologic conditions	Patient reported outcome	**Participation.** Multidimensional measurement assessing the subjective experiences of participants when developing an activity	-	-	-	-(Ellapis and Peterlin Perisk 2018) -(Nijenhuis et al. 2017) -(Rowe et al. 2017)
ABC (1995)	Balance, self-efficiency after stroke	Stroke	Performance based	**Activity.** perceived level of balance confidence in activities of daily living	-	-	-	-(Gambelli et al. 2017) -(Kannan et al. 2018) -(Lee et al. 2017)
ARAT (1991)	UE	Stroke	Performance based	**Body Structure, Function. Activity.** Evaluative measure of UE motor ability and dexterity	StrokEDGE consensus panel recommendations (Bushnell et al. 2011)	-	For chronic stroke: use a 10% change on the total score	-(Given et al. 2016) -(Nijenhuis et al. 2017) -(Rowe et al. 2017)
9HPT (1985)	Finger dexterity	Neurologic conditions	Performance based	**Activity.** The test uses a wooden or plastic board with 9 ½" pegs.	StrokEDGE Taskforce Responsive measure of change in people with PD	"normal" is a completion in 18 ± st Dev.(0-5peg/s).	-	-(Aller et al. 2017) -(Jonsdottir et al. 2018) -(Rowe et al. 2017)
FIM (1983)	Disability	Neurologic conditions	Performance based	**Activity.** Measurement of disability, according to the ICF. Consists 18 items (13 motor and 5 cognitive tests). FIM subscales could be of interest (e.g. transfer and locomotion).	StrokEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce	-	22 points	-(Given et al. 2016) -(Barasa et al. 2018) -(Jacquet and Çakmak 2018)
Subjective perception (VAS, Borg) (1921; 1960)	Pain, discomfort, difficulty	Neurologic conditions	Self-report	**Body Function, Structure.** Assessment of subjective perception while performing tasks/activities	-	-	-	-(Ferraz et al. 2018) -(Norouzi-Gheidari et al. 2019) -(Jacquet and Çakmak 2018)
SIS (1999)	Health status and QoL, self-efficiency after stroke	Stroke	Self-report questionnaire	**Activity/Participation.** 9 domains with 59 items) • Strength • Hand function • ADL/IADL • Mobility • Communication • Emotion • Memory and thinking • Participation/Role function. A final item is on stroke recovery perceived (0 = no recovery; 100 = full recovery)	StrokEDGE consensus panel recommendations (Bushnell et al. 2011)	24.0, 17.3, 11.2, and 21.3, respectively for strength, ADL/IADL, mobility, and hand function subscales	9.2, 5.9, 4.3, and 13.8 respectively for strength, ADL/IADL, mobility, and hand function subscales	-(Lee et al. 2017) -(Nijenhuis et al. 2017) -(Norouzi-Gheidari et al. 2019)
EuroQol-5D (2001)	Health	Neurologic conditions	Patient reported outcome	**Body Structure, Function, Participation.** Assess problems in 5 dimensions: mobility, self-care, usual activities, pain/discomfort, anxiety/depression	StrokEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce	-	-	-(Ferraz et al. 2018) -(Tüzün et al. 2019)

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Tabella III. *(segue)*

Outcome measure/ measurement mode	Target	Neurological population to which it refers	Type of measure	Domains	Inclusion in core-set	MCID	MCID	Reference to reviewed papers
UPDRS- UPDRS-II (1985)	Health	PD	Patient reported outcome	**Body Function, Activity, Participation.** Comprehensive assessment designed to monitor the burden and extension of PD across the longitudinal course of illness.	StrokEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce	-	3.1 points	-(Cakit and Petrelis Polisk 2018) -(Tollár et al. 2019)
MAS (1987)	Spasticity	MS, stroke	Performance based	**Body Structure, Function.** Spasticity	StrokEDGE TaskForce	-	1 point decrease (also as response to Botox)	-(Magyar et al. 2019) -(Jergová and Jakuk 2018)
BDI (1961)	Emotion	Neurologic conditions	Patient reported outcome	**Body Function.** Quantifies severity of depression.	-	Scores>10 indicate depression	-	-(Rowe et al. 2017) -(Tollár et al. 2019)
NIHSS (1997)	Deficit	Stroke	Performance based	**Body Structure, Function.** Quantitative measure of neurological deficit post stroke (LOC, ability to respond to questions and obey simple commands, papillary response, deviation of gaze, homonymous, facial palsy, resistance to gravity in front limb, plantar reflexes, limb ataxia, sensory loss, visual neglect, dysarthria, and aphasia).	StrokEDGE TaskForce	-	-	-(Lapin et al. 2018) -(Rowe et al. 2017)
TMT (1958)	Cognitive abilities	Neurologic conditions	Performance based	**Activity.** Processing speed and executive function.	-	-	-	-(Allen et al. 2017) -(Jung et al. 2018)
dynamometry	Force	Neurologic conditions	Performance based	**Body Structure.** Assessment of grip/pinch force.	StrokEDGE TaskForce	-	-	-(Severin et al. 2016) -(Nijenhuis et al. 2017)
WMFT (1989)	UE	Stroke	Performance based	**Activity.** 15 timed movement tasks and 2 strength-based tasks	StrokEDGE consensus panel recommendations (Bushnell et al. 2015)	-	1.5 seconds	-(Hung et al. 2019) -(Magyar et al. 2019)
5 STS (2011)	Transfer skill	Neurologic conditions	Performance based	**Activity.** Multi-dimensional task that relies on LE strength and balance.	StrokEDGE TaskForce, Parkinson TaskForce, Multiple Sclerosis TaskForce; (Best practice evidence)	Cut-off score of 15 sec. was predictive of falters in elderly	Cut-off score of 12 secs is discriminatory between healthy elderly and subjects with (recent) stroke	(Portas et al. 2018)
PDQ8 (1999)	Quality of life and overall status	PD	Patient reported outcome	**Activities, Participation.** Eight domains: mobility, ADL, emotional well-being, stigma, social support, cognition, communication, and bodily discomfort.	-	-	5.7-7.4 points	(Gandolfi et al. 2017)
WHODAS 2.0 (1980)	Health and Disability	Neurologic conditions	Patient reported outcome	**Activities, Participation.** Assess individual difficulties in different domains: cognition, mobility, self-care, getting along with others, life activities, participation. Score on 5 points ordinal scale (3=none, 4 = extreme).	-	-	-	(Portas et al. 2018)
DGI (2001)	Balance while walking	Neurologic conditions	Performance based	**Activities.** Ability to modify gait in response to task demands.	-	-	1.80 for older adults: with a DGI score = 21/24	(Gandolfi et al. 2017)
BMT (1992)	Hand functions	Stroke	Performance based	**Activities.** Evaluates unilateral manual performance in hemiparetic patients after stroke.	-	-	-	(Lee et al. 2018)
TAT (1986)	Balance and gait	Neurologic conditions	Performance based	**Activity.** Balance and gait subscale.	-	Elderly individuals scoring <31 on the balance test have a high risk of falling	-	(Tollár et al. 2019)
BESTest (2009)	Balance	Neurologic conditions	Performance based	**Body Structure, Function, Activity.** 27 tasks with a total of 36 item grouped into 6 systems.	-	-	-	(Tollár et al. 2019)
SE-ADL (1969)	Independence	PD and neurologic conditions	Performance based	**Activity.** Assessment of functioning in ADL.	-	12.93	-	(Tollár et al. 2019)
Katz IADL (1963)	Independence	Neurologic conditions	Performance based	**Activity.** 6 basic ADL observed	-	-	-	(Glover et al. 2016)
RMI (1991)	Gait, Balance and transfers	Stroke	Performance based	**Body Structure, Function.** 14 self-reported items and 1 direct observation item	StrokEDGE TaskForce	-	-	(Lapin et al. 2018)

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Tabella III. *(segue)*

Outcome measure/ measurement mode	Target	Neurological population to which it refers	Type of measure	Domains	Inclusion in core set	MCD	MCID	Reference to reviewed papers
Barthel Index (1965)	Self-care, independence	Stroke	Performance based	**Activity.** Assesses the ability of an individual to care for him/herself.	-	-	19 points	(Lupo et al. 2018)
SNS (1986)	Motor and cognitive functions	Stroke	Clinician rated instrument	**Body Function. Activity.** Neurological assessment of cognition and motor functions.	-	-	-	(Lupo et al. 2018)
PRPS (2004)	Motivation	Stroke; Spinal Cord Injury	Clinician rated instrument	**Body Function. Participation.** Assesses a patient's participation in therapy.	-	-	-	(Lupo et al. 2018)
SF-12 (1996)	Health	Neurologic conditions	Patient reported outcome	**Participation.** Physical and mental health.	StrokEDGE Taskforce	-	-	(Amouzandeh et al. 2018)
FASS (1999)	Balance, transfer	Stroke	Performance based	**Activity.** Assesses the ability to maintain or change a given lying, sitting or standing as well as move between these postures.	StrokEDGE Taskforce	-	-	(Karlsen et al. 2016)
CSRT (2001)	Balance	Neurologic conditions	Performance based	**Body Function. Activity.** Strong predictor of falls in older adults.	-	-	-	(Dong et al. 2016)
FGA (developed as a modification of the DGI) (2000)	Balance while walking	Stroke	Performance based	**Body Function. Activity.** Strong predictor of falls in community-dwelling older adults.	CPG APTA (Moore et al. 2019)	4.3 d	-	(Dong et al. 2016)
NFGq (2009)	Gait	PD	Self-report	**Body Function. Activity.**	-	-	-	(Kong et al. 2016)
FESiq (2005)	Concerns about falling	Neurologic conditions	Self-report	**Activity.** 10 item questionnaire that assesses confidence in performing daily activities without falling.	StrokEDGE Taskforce			(Dong et al. 2016)
M-PAES (2011)	Emotion	Neurologic conditions	Self-report	**Activity. Participation.** Assesses enjoyment in physical activity.	-	-	-	(Lee et al. 2017)
FSS (1989)	Fatigue	MS and neurologic conditions	Self-report	**Body Function.** Measures the severity of fatigue and its effect on ADL and lifestyle.	-	A score >4 indicates fatigue	-	(Rikos et al. 2017)
NASM q (1999)	Hand dexterity	Neurologic conditions	Patient reported outcome	**Activity.** Assessment of hand function based on the patient's responses to functional questions.	-	-	-	(Allen et al. 2017)
NHP (1970)	General health	Neurologic conditions	Patient reported outcome	**Participation.** Assesses perceived health (encompassing the social and personal effects of illness)	-	-	-	(Jonjalé and Cvitok 2016)
BRAIN TEST (2009)	Finger dexterity	PD	Performance based	**Activity.** Movement speed and accuracy.	-	-	-	(Allen et al. 2017)
CBT (2009)	Hand dexterity	Neurologic conditions	Performance based	**Activity.** Movement speed and accuracy.	-	-	-	(Allen et al. 2017)
Accelerometry	Walking	Neurologic conditions	Performance based	**Activity.** Assessment of number of daily steps.	-	-	-	(Dixon et al. 2016)

Legend (alphabetical order) for Tables I, II, and III.

ABC - Activities-Specific Balance Confidence scale
ARAT - Action Research Arm Test
ATI - Average minimal indication
ATeMI - the average time of manipulation
BBS - Berg Balance Scale
BBT - Box and Block Test
BDI - Beck Depression Inventory
BESTest - Balance Evaluation Systems Test
BHS - Beck Hopelessness Scale
BI - Barthel Index
BRAIN TEST - BRadykinesia Akinesia INcoordination Test
CNS - Canadian Neurological Scale
cog TUG - cognitive Timed-Up and Go
CoP - Center of pressure), the path length (PL) and sway velocity (SV)
CRT - Core Rotation Task
CSRT - Choice Stepping Reaction Time Test
DGI - Dynamic Gait Index
EQ-5D - EuroQol 5 Dimensions Questionnaire
EQ-VAS - EQ-5D visual analogue scale
FESiq - Fall Efficacy Scale–International questionnaire
FGA - Functional Gait Assessment
FIM - Functional Independence Measure: transfer (FIMt) and locomotion (FIMl)
FMA - Fugl-Meyer Assessment
FRT - Functional Reach Test
FSS - Fatigue Severity Scale (BR: Brazilian version)
GDS - Geriatric Depression Scale
Katz IADL - Katz Index of IADL
lB - the number of inserted cubes
IMI - Intrinsic Motivation Inventory
LNS - letter-number sequencing task
LOS - the limits of stability test
MAL - Motor Activity Log, Amount of Use (MAL-AOU), Quality of Movement (MAL-QOM)
MAMAs - Maimuri Ability Measure questionnaire
MAS - Modified Ashworth Scale
mBI - modified Barthel Index
MoCA - Montreal Cognitive Assessment
mRFT - modified Functional Reach Test
MVT - Manual Function test
m-PAES – mod Physical Activity Enjoyment scale
MVL - movement velocity
NFGq - New Freezing of Gait questionnaire
NHP - Nottingham Health Profile
NIHSS - National Institutes of Health Stroke Scale
OLS - one-leg stance test
PASS - Postural Assessment Scale for Stroke Patients
PDQ8 - Parkinson's Disease Quality of Life questionnaire
PDQ39 - Parkinson Disease Questionnaire-39
PRPS - Pittsburgh Rehabilitation Participation Scale
PL - path length
RMI - Rivermead Mobility Index
SBI - Sway Balance Index (measured by Kinesthetic Ability Trainer, KAT)
SE-ADL - Schwab and England Activities of Daily Living scale
SF12 - 12-Item Short Form Survey
SIS - Stroke Impact Scale
SPT - Slip Perturbation test
SST - Sitting-rising Test
SW - sway velocity
TAT - Tinetti Assessment Tool
TDT4E - Time from first touch to end
TMT - Trail Making Test (part A and B)
TNaT - the total number of trials
TUG - Timed Up and Go
UPDRS - Shortened Unified Parkinson's disease rating scale
UPDRS-II - Movement Disorders Society Unified Parkinson's Disease Rating Scale
WMFT - Wolf Motor Function Test
WHODAS 2.0 - World Health Organization Disability Assessment Schedule 2.0
5 STS - 5 times Sit-to-Rise Test
6MWT - 6 min Walking Test
9HPT - 9 Hole Peg Test
10 MWT - 10 min Walking Test

generalizable data, due to the smallness of the samples, the variability of the training methods and dosage, as well as the poor control of the results at follow-up. In our opinion, a certain fragility of the conclusions also derives from the heterogeneity of the outcome measures used among the studies. In many respects, EG based rehabilitation meets the indications of the rehabilitation guidelines (43): high repetition and task-oriented training; combined exercises; fall prevention; hand dexterity and fine motor skills; home rehabilitation; prevention of secondary disabilities. The studies we have analyzed, randomized controlled trials published in the last 5 years on the use of EG in the rehabilitation of the older adult, suggest interesting developments especially in relation to the training of mobility, balance and postural control, as well as of coordination and hand dexterity. All these motor skills affect independence and quality of life of neurological patients. The EG based rehabilitation allows for large volumes of exercise by customizing tasks training and stimulating patient motivation. In particular, remote monitoring of physical activity throgh EG based rehabilitation represents a significant opportunity for the management of patients at home and in continuity of care.

Although our main focus was on the use of EGs, regardless if associated with immersive or non-immersive VR, we found that 18 of the 24 included articles (75%) used "virtual reality" in association with "exergame", and without a clear distinction between the two terms. Only in three articles, EG (easy-to-use and cost-effective commercial games) and VR (specific tools for rehabilitation) were treated as distinct techniques, but without reporting an obvious advantage of one over the other.

Training based both on EG and VR leads to savings in terms of staff employed and convenience. Excellent adherence to therapy and a greater total amount of exercise accumulated by patients are a strength, which can also contribute to improvements in quality of life, regardless of the type of exercise (26).

In the future, a more functional and task oriented EG design could increase the efficiency of motor learning in patients (41) and encourage the acquisition of more efficient automatic behaviours (44). Mitigation of some critical issues relating to home-based training may occur in the future also thanks to the refinement of innovative techniques, such as robotics and exoskeletons. However, directly available care and supervision of patients with high disease severity remains a key aspect of home rehabilitation. Training at home using platforms that involve multiple users in the game could be a valid modality for the remote rehabilitation of patients with mild illness; however the effects of this methodology have not been explored in the literature so far (only the study by Thielbar et al. employs part of the experimental group in multi-user mode). The high involvement of patients in VR and EG could induce some disadvantages, typically due to the perception of time pressure, and consequently low precision in exercise execution, compensatory movements or tremors, as well as greater postural instability and even risk of falling. A key point still to be clarified are the recommendations on the type and dosage of training based on the severity of the disease and the patient's cognitive abilities. The duration and intensity of rehabilitation, generally short in the studies analyzed, could be decisive for a greater relevance of the outcomes.

Since neurological patients have a high potential for motor improvement even after discharge from the hospital, training based on VR and EG could represent a valid alternative to traditional rehabilitation in the perspective of continuity of patient care. The studies analyzed, although within the limits highlighted, show that VR and EG can be included in a training program for patients who have suffered from stroke, PD or MS. The rehabilitative effects obtained with EG-VR are generally comparable to those obtained through traditional rehabilitation and appear to benefit mainly patients with mild to moderate disease severity.

Several questions emerge from the analyzed studies, which will have to be answered in the future:

- find out which factors influence the patient's acceptability, motivation and adherence to therapy (28,37,39,40,41,42);
- verify to what extent the patient's physical characteristics such as muscle strength, lean mass (23) or obesity (32) affect motor recovery, and how the benefits obtained can be maintained over time (26,28,38);
- which variables to monitor during exercise, to more precisely control intensity and tolerability (34);
- better define the conditions for tele-rehabilitation (9,11,28,39) also considering new modalities (eg wearable exoskeletons) (27);
- study of the rehabilitation of the lower limb (41);
- verify the effects associated with different exercise programs on important outcome measures such as fitness and mobility, quality of life, daily activities, cost-benefit ratio, fall risk and muscle strength (34), and verify functional relapses (40);
- performing studies on much larger sample sizes, including other pathologies, to confirm the clinical efficacy of the approaches (24,39,42) and to investigate the superiority of EG and VR over conventional programs (30,32);
- explore the interaction between cognitive aspects and motor therapy interventions (40).

In rehabilitation, appropriate selection of outcome measures is essential to obtain informative data on the efficacy of treatments and to assess the change over time of motor and functional aspects, as recommended by clinical practice guidelines (45) and by the StrokEDGE consent group (46). A fundamental set of recommended outcome measures for the neuro-rehabilitation of the older patient is still missing. Recent stroke guidelines (47,48) recommend the use of primary and secondary outcome measures, which include measures of impairment, activity limitation, and quality of life, and with established psychometric properties. Self-assessment measures should complement objective measures to assess functional gain and motivational aspects.

Many of the scales used in the studies analysed (Berg Balance Scale, Fugl-Meyer, Balance Confidence Scale, Functional Gait Assessment, 10-meter Walk Test and 6-

minute Walk Test) are recommended as primary outcome measures for neurological conditions in adults. Other, such as the Wolf Motor Function Test, the Action Research Arm Test, the ten-meter and six-minute Walk Tests, and the Stroke Impact Scale, are recommended as secondary outcomes. Subjective patient experience has often been evaluated in studies through the Intrinsic Motivation Inventory (49).

Our review was thorough in examining the RCTs found in databases and offering an integrated view on the technical, individual and rehabilitative aspects of the problem. It is possible however, that some interesting works including "grey literature" have not been addressed.

Regarding the limitations of our study, it was not possible to compare the long-term benefit obtained from a specific platforms used in patients with the same pathology, or with the same characteristics in terms of age, sex and severity of motor disorders. Limited duration of the trial in the studies and variety of platforms, training methodologies and outcome measures helped to blur homogeneous conclusions. Furthermore, in the samples studied, already numerically scarce, the female gender was very little represented (4%), which could also generate an imprecise knowledge of the motivational and functional aspects related to exercise, generally different between male and female (50,51). The lack of standardization between studies with respect to the rehabilitation protocol is an aspect that should be improved in future in this research area.

Conclusions

The EG rehabilitation of the older adult with stroke, PD or MS seems to offer multiple advantages. However, to date it is not possible to draw precise indications on the effectiveness and optimal treatment methods for the various pathologies, especially in relation to functional recovery.

Further efforts are needed to collect data on larger samples and analyze them according to an agreed research direction, also by better defining the significant parameters to be evaluated through more homogeneous and standardized outcome measures.

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Strategie preventive per la movimentazione manuale dei pazienti in una grande azienda ospedaliera

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RIASSUNTO. L'attività di movimentazione manuale dei pazienti (MMP) ed un'età anagrafica media sempre più elevata degli operatori sanitari aumentano il rischio di disturbi e patologie dell'apparato muscoloscheletrico, causando assenze dal lavoro per malattia. L'adozione di interventi mirati, supportati dal management, ha dimostrato efficacia per la sicurezza dei lavoratori e può indurre una migliore qualità dell'assistenza.
Obiettivo. **Riportare una esperienza significativa di strategie preventive adottate in un grande ospedale milanese tramite la figura di un ergocoach (ergoformatore).**
Metodi. **È stato condotto un complessivo piano di riduzione del rischio da movimentazione pazienti tramite un preliminare progetto pilota e successivi interventi preventivi (fornitura attrezzature, formazione all'utilizzo e verifica di efficacia) estesi a tutte le unità operative in periodi successivi.**
Risultati. **In tutte le unità operative si è raggiunta una riduzione del rischio da movimentazione manuale dei pazienti; tuttavia si evidenzia la permanenza di alcuni compiti sovraccaricanti che necessitano di una complessiva gestione nel tempo.**
Conclusioni. **L'approccio delle strategie preventive adottate per la riduzione del rischio da movimentazione manuale dei pazienti nell'azienda ospedaliera (valutazione del rischio specifico, fornitura di adeguate attrezzature, formazione teorico pratica all'utilizzo delle stesse e supporto on the job) ha dimostrato il raggiungimento di risultati in termini di riduzione del rischio da movimentazioni pazienti che, per essere mantenuti nel tempo, necessitano di continue verifiche.**

Parole chiave: Movimentazione manuale dei pazienti, ergoformatore, sovraccarico biomeccanico, attrezzature.

ABSTRACT. Preventive strategies for patient manual handling in a major hospital. Patient manual handling (MHP) and an increase in the average age of the healthcare workforce increase the risk of musculoskeletal disorders and diseases, leading to sickness absence. Targeted interventions, supported by management, have been proven effective for workplace safety and can lead to improved quality of care.

Key words: *Patient manual handling, Ergocoach, Biomechanical overload, Equipment.*

1. Introduzione

I disturbi muscoloscheletrici rappresentano uno dei principali problemi nel settore sanitario per i lavoratori che si occupano di movimentazione manuale dei pazienti. È ormai ampiamente dimostrata da diversi studi scientifici (1, 2, 3, 4, 5, 6) la correlazione tra attività lavorativa di sollevamento manuale dei pazienti e rischio d'insorgenza dei disturbi muscoloscheletrici, in particolare al rachide lombare. Già dagli anni '90 studi di biomeccanica (7, 8, 9) hanno messo in evidenza come la MMP induca delle forze compressive sul disco intervertebrale lombare superiore al limite di tolleranza definito in 275 kg per le donne e 400 kg per gli uomini (10). Studi effettuati dal 1999 al 2007 (11, 12, 13) hanno dimostrato che i compiti di trasferimento manuale pazienti superano sempre i limiti di tolleranza. Viene quindi fortemente raccomandato l'uso delle attrezzature come unica soluzione per ridurre concretamente il rischio di Low Back Pain (LBP).

Alcuni studi multicentrici di correlazione rischio-danno effettuati in Italia (14, 15) evidenziano che il personale addetto all'assistenza può raggiungere una prevalenza di ernie discali lombari pari al 17%, mentre in popolazioni lavorative amministrative (considerato come gruppo di lavoratori non esposti al rischio) la prevalenza varia dal 3,5 al 4% (16).

Cofattore di rischio è rappresentato dall'età anagrafica media dei lavoratori in sanità, come si evidenzia dall'E-BOOK della Consulta Interassociativa della Prevenzione (CIIP) inerente il rapporto tra invecchiamento e lavoro (https://www.ciip-consulta.it/): un'età media elevata induce una "ipersuscettibilità" alle forze compressive aumentando il rischio di sviluppare disturbi muscoloscheletrici per una diminuita tolleranza delle strutture anatomiche (17, 18). La comunità scientifica internazionale, in merito agli orientamenti delle strategie preventive nell'esposizione al rischio da MMP, si è indirizzata inizialmente verso studi di formazione specifica che non hanno dimostrato risultati significativi in riduzione dei disturbi lombari (19, 20). I migliori risultati (notevole riduzione delle assenze per LBP e dei costi ad esse connessi) si sono raggiunti tramite acquisto attrezzature, formazione specifica e coinvolgimento del management (21, 22, 23).

Un'esperienza significativa, con l'obiettivo di integrare l'ergonomia nella cultura ospedaliera, è stata condotta in un grande ospedale del Regno Unito (24): i risultati nel corso di un processo durato cinque anni sono stati sia ambienti più sicuri che diminuzione degli infortuni e riduzione dei giorni di assenze per malattie muscoloscheletriche.

Analogo progetto preventivo è stato effettuato nel 2012 in 5 RSA e in 1 ospedale (25) ed i risultati sono stati una notevole riduzione dei disturbi muscoloscheletrici e soddisfazione sia dei lavoratori che dei pazienti.

Nel 2012 viene pubblicato dall'ISO (Ente normativo Internazionale) il Technical Report TR 12296 (26) sulla gestione del rischio da movimentazione pazienti in area assistenziale con due obiettivi: migliorare le condizioni di lavoro degli operatori addetti alla movimentazione pazienti e migliorare la qualità dell'assistenza.

Nel TR sopra citato viene riportata una review bibliografica inerente le modalità più efficaci nel campo delle strategie preventive. I migliori risultati a livello internazionale si sono ottenuti attraverso la condivisione delle strategie a livello di direzione aziendale; in particolare alcuni stati si sono indirizzati a configurare specifiche figure di ergocoach (denominati anche peer leaders o ergoleaders) per gestire il rischio da movimentazione dei pazienti e implementare efficaci strategie preventive durevoli nel tempo. Tali figure si sono dimostrate delle efficaci risorse interne aziendali (27, 28).

La figura professionale dell'ergocoach è stata costituita tramite normativa governativa in Olanda e si è diffusa a livello internazionale (26) con l'obiettivo comune di effettuare efficace formazione all'utilizzo delle attrezzature fornite.

Scopo del presente contributo, partendo da una review delle stratregie preventive per la riduzione del rischio da movimentazione manuale pazienti, è presentare l'applicazione di un piano di riduzione del rischio in uno dei principali ospedali milanesi.

2. Materiali e metodi

L'ospedale preso in considerazione è la Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico di Milano, costituito da 900 posti letto e da 1.200 operatori esposti al rischio da movimentazione manuale pazienti (MMP).

Inizialmente è stata identificata una risorsa che, a seguito di un'adeguata formazione (completata nel 2011), si potesse dedicare a tempo pieno alla gestione del rischio da movimentazione manuale dei pazienti all'interno dell'azienda sanitaria.

La formazione specifica si è svolta presso la sezione di Ergonomia dello stesso Ospedale ed ha compreso sia la formazione sulla valutazione dei rischi in ergonomia fisica (movimentazione carichi, pazienti, movimenti ripetitivi, posture incongrue) che la formazione specifica in qualità di ergoformatore (ergocoach).

Obiettivo successivo è stato l'impostazione di un piano preventivo di riduzione del rischio da MMP: in Figura 1 viene presentato lo schema riepilogativo delle strategie preventive adottate dal 2011 ad oggi.

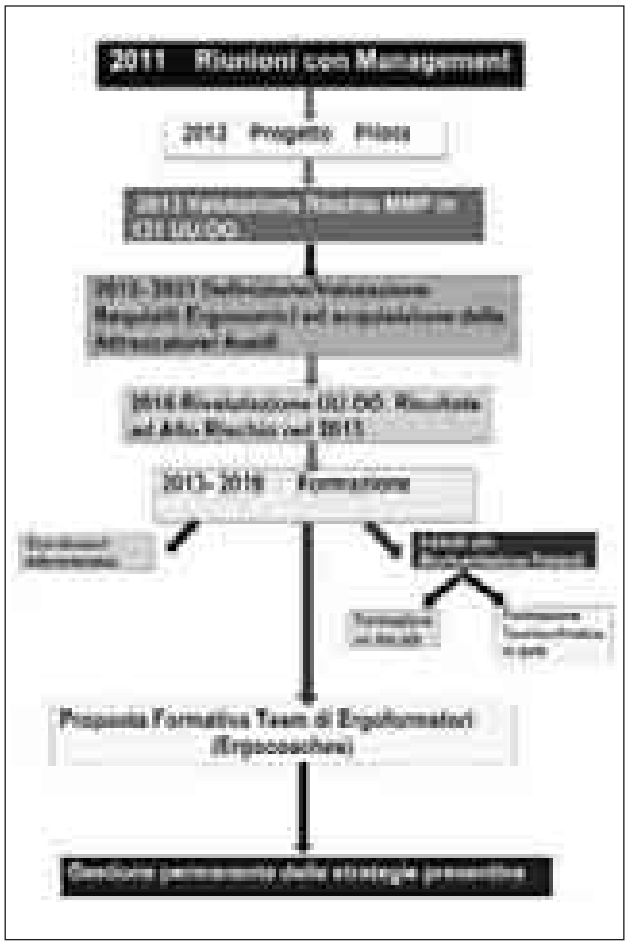

Figura 1. ***Strategie preventive impostate dal 2011 al 2019***

Inizialmente si sono effettuati incontri con la dirigenza (Direttore Generale, Responsabile servizio prevenzione e protezione - RSPP, Responsabile Formazione Aziendale, Responsabile Ufficio infermieristico, Responsabile Formazione sanitari non medici, Medico Competente, Responsabile infermieristico di dipartimento, Rappresentante dei lavoratori per la sicurezza) finalizzati a condividere un progetto di riduzione del rischio specifico.

Al termine di questi incontri si è deciso di iniziare un preliminare "progetto pilota" indirizzato ad un padiglione dell'azienda ospedaliera costituito da 4 degenze, 4 servizi/DH ed un blocco operatorio. Il progetto si è sviluppato in momenti differenti a partire dalla valutazione del rischio da MMP tramite metodologia MAPO (29), identificazione dei bisogni di ausiliazione e successiva acquisizione, formazione del personale (n° 153 lavoratori) e verifica di efficacia degli interventi messi in atto in tre degenze ed un servizio. Per la scelta delle attrezzature si è fatto riferimento alle caratteristiche ergonomiche definite dalla review delle linee guida Internazionali effettuata nel TR 12296.

In Tabella I vengono definiti i requisiti ergonomici fondamentali da differenziare per ogni tipologia di attrezzatura (30, 31).

Tabella I. ***Requisiti ergonomici fondamentali per le attrezzature/ausili***

Requisiti ergonomici preliminari che ogni singola attrezzatura deve soddisfare	Requisiti ergonomici specifici che ogni singola attrezzatura deve soddisfare
Sicurezza paziente	Adattabilità ai pazienti
Sicurezza operatore	Adattabilità alle movimentazioni
Confort per paziente-operatore	Adattabilità ambienti-arredi
Basso sforzo fisico applicato	Semplicità di utilizzo

2.1. Progetto pilota: formazione degli operatori

Il progetto formativo si è sviluppato in due giornate, la prima di 4 ore di teoria con lezione frontale (20 partecipanti), la seconda a distanza di tre settimane, sempre di 4 ore, ma dedicate all'addestramento delle attrezzature presenti nelle UU.OO. simulando scenari della realtà lavorativa con gruppi di 10 partecipanti. In queste prime edizioni sono stati coinvolti sia gli operatori addetti alla MMP che i coordinatori.

Per ogni edizione è stato individuato un referente di U.O. con l'obiettivo di monitorare l'utilizzo delle attrezzature e contattare per particolari necessità il responsabile della formazione specifica; contestualmente è stata consegnata una dispensa educativa come supporto alla formazione teorica/pratica.

È stato successivamente programmato un tutoraggio sul campo per verificare il corretto utilizzo delle attrezzature.

A distanza di tre anni dall'acquisizione delle attrezzature fornite e dalla formazione erogata al 100% degli addetti, è stata effettuata la verifica di efficacia, che ha previsto un'osservazione delle manovre con protocollo specifico (30) finalizzato a valutare le posture assunte e l'utilizzo degli ausili; in particolare si sono osservati gli operatori presenti nei turni mattino e pomeriggio, per più giorni, durante l'attività iniziale di igiene e mobilizzazione abitualmente denominata "giro letti". Inoltre dagli operatori esposti è stata compilata (n° 64 lavoratori) una scala visuo-analogica 0-10-Borg (32) per lo sforzo percepito, sia per manovre manuali che tramite ausili. Altro strumento utilizzato per verifica dell'efficacia è stata la scheda analitica MAPO con cui si è rivalutato il rischio da MMP; tuttavia, nel corso del processo messo in atto, si sono incontrate alcune difficoltà di seguito elencate:

– turnover del personale addetto alla movimentazione pazienti, che ha determinato difficoltà nel confronto pre-post formazione per verificare le modalità di utilizzo delle attrezzature fornite;
– difficoltà a far permanere le attrezzature fornite nelle diverse realtà lavorative, che ha determinato un continuo e necessario controllo da parte dell'ergoformatore.

L'analisi dei limiti del "progetto pilota" ha consentito di programmare una formazione, per tutte le altre UU.OO., differente in termini organizzativi e di contenuti.

Successivamente è stato programmato un incontro con la dirigenza infermieristica per condividere le difficoltà incontrate e le proposte future. Si è proseguito prendendo in considerazione un intervento formativo specifico per i coordinatori con la collaborazione del Responsabile del Servizio Prevenzione e Protezione.

2.2. Analisi dei dati del "Progetto Pilota"

Nella gestione dei dati si è posta particolare attenzione alla riduzione del livello di rischio e all'adozione di modalità di MMP meno sovraccaricanti (tramite la percentuale di movimentazione ausiliate).

Si è inoltre quantificato lo sforzo percepito tramite scala di Borg nelle 64 schede pervenute. In particolare quest'ultimo è stato espresso come valore medio per le manovre manuali e confrontato con il valore medio della stessa tipologia di manovra effettuata tramite attrezzature; la quantificazione dello sforzo è stato suddiviso in classi di basso sforzo – medio sforzo – alto sforzo (32).

Ci si è avvalsi del software statistico SPSS sia per l'analisi descrittiva dei dati, che per i confronti utili alla verifica di efficacia (test t per dati appaiati).

2.3. Proseguimento della valutazione del rischio e delle strategie preventive

Il progetto delle strategie preventive messo in atto è proseguito nell'anno 2013 con la valutazione del rischio di tutte le altre Unità (122 tra degenze, blocchi operatori e servizi) al fine di programmare un piano di riduzione del rischio tramite la fornitura di attrezzature e la formazione di tutto il personale addetto alla MMP.

Nei risultati verrà presentato il piano di effettiva fornitura delle attrezzature nel periodo 2012-2016.

La valutazione del rischio ha permesso di evidenziare le percentuali di operatori per fasce di rischio: questo ha consentito di stabilire delle priorità di intervento, in quanto inizialmente si è indirizzata la formazione agli operatori nelle UU.OO. ad esposizione maggiore per poi proseguire con tutti gli operatori esposti al rischio MMP.

La formazione teorico-pratica è stata svolta in un'unica giornata (8 ore) per semplificare la partecipazione del personale; successivamente alla formazione, è stata effettuata nel 2016 una rivalutazione del rischio prioritariamente nei reparti/settori ad alto rischio.

Non è stato possibile effettuare un confronto dei risultati ottenuti per tutte le unità valutate a causa dell'elevato turnover dei lavoratori. Il confronto è stato possibile in qualità di stima di verifica di efficacia (considerando la riduzione del livello di esposizione) in 22 UU.OO., a distanza di tre anni, tramite la complessiva valutazione del rischio da MMP.

Il proseguimento del progetto prevedeva il completamento della formazione al 100% degli esposti in azienda,

ma tale processo si è reso difficile dalle variabili abitualmente presenti nell'azienda ospedaliera considerata: turnover personale, riorganizzazioni per profili professionali, nuove assunzioni e pensionamenti, nonché ristrutturazione completa di nuovi padiglioni.

Per la gestione permanente della formazione e per raggiungere gli obiettivi inizialmente concordati con il management aziendale, nel 2017 si è proposto di costituire un gruppo di ergoformatori (come ormai da parecchi anni la letteratura internazionale raccomanda) guidati e supportati dalla figura di un coordinatore degli ergoformatori già presente in azienda con la funzione di coordinamento del gruppo.

L'aggiornamento della valutazione del rischio con rispettive indicazioni di ulteriori attrezzature da acquisire permane il substrato su cui impostare le azioni successive.

Nel 2019 è stato programmato un aggiornamento della valutazione del rischio effettuato in sole 26 UU.OO. su 131 esistenti in azienda per subentrata pandemia.

3. Risultati

3.1. Progetto pilota

Tutti gli interventi previsti hanno portato all'acquisizione delle attrezzature indicate, alla formazione della totalità degli addetti alle attività di MMP e dei coordinatori dei reparti specifici.

In Tabella II viene effettuato un confronto tra la situazione iniziale e quella successiva al piano preventivo adottato nelle UU.OO. del progetto pilota: viene esplicitato il livello di rischio e le percentuali di utilizzo delle attrezzature. Per effettuare questo confronto è stato utilizzato, sia per le movimentazioni di pazienti NC (% sollevamenti Totali ausiliati) che di pazienti PC (% sollevamenti Parziali ausiliati), un test t per dati appaiati che è risultato, in entrambi i casi, significativo (p= 0,1).

Dall'osservazione diretta nei due turni di lavoro (mattino e pomeriggio) si è potuto constatare che le attrezzature venivano utilizzate con un buon risultato soprattutto nel sollevamento di pazienti non collaboranti (NC) da sollevare totalmente, raggiungendo anche un 100% di movimentazioni ausiliate in neurochirurgia, come si può vedere in Tabella II. Per il sollevamento di pazienti da sollevare parzialmente (PC) si sono raggiunte percentuali di ausiliazione inferiore, con range variabile tra il 18% e 70%. Sempre in Tabella II si può osservare una riduzione del livello di rischio tranne in un reparto, dove sono subentrati pazienti più critici rispetto alla prima valutazione.

In Tabella III si illustrano i risultati dello sforzo percepito (32) nelle tre movimentazioni di sollevamento/trasferimento più frequenti nelle UU.OO. considerate. Per agevolare una lettura comparativa dei dati inerenti il tempo T0 e Tn si esprimono i risultati come mediana e range interquartile.

Si evidenzia una notevole riduzione dello sforzo percepito tramite l'utilizzo di attrezzature (letto ergonomico, teli ad alto scorrimento e tavola ad alto scorrimento).

3.2. Risultati della valutazione del rischio e delle strategie preventive condotte sulle 131 UU.OO

Nelle Tabelle IV e V vengono presentati i complessivi risultati della valutazione rischio nelle 131 UU.OO. da cui emerge come il 37,4% delle UU.OO. sia ad alto-medio rischio con 844 lavoratori esposti a rischio medio-alto.

Le attrezzature indicate dal documento di valutazione del rischio sono state fornite parzialmente come emerge dalle percentuali riportate in Tabella VI; il numero maggiore di carrozzine acquisite rispetto a quelle richieste ri-

Tabella II. ***Confronto indice di rischio con percentuale di ausiliazione per U.O. prima e dopo le strategie preventive***

RISULTATI PROGETTO PILOTA						
	T0= 2012			Tn= 2015		
Reparti	MAPO	% sollev. totali ausiliati	% sollev. parziali ausiliati	MAPO	% sollev. totali ausiliati	% sollev. parziali ausiliati
Neurochirurgia	medio	16	10	trascurabile	100	40
Neurologia	elevato	20	0	medio	50	37,5
Polichirurgico Adulti	medio	0	0	medio	80	18
Neuroradiologia	elevato	0	0	medio	50-70	50-70

Tabella III. ***Mediana e range interquartile della valutazione sforzo percepito con scala visuoanalogica 0-10 (Borg) per sforzo percepito durante le movimentazioni dei pazienti***

Mediana e range interquartile della valutazione sforzo percepito con scala (0-10, Borg) per i compiti svolti manualmente confrontati con stessi compiti svolti con ausili (n=64 operatori)					
Sollevamento verso il cuscino (letto-teli)		Rotazione per cambio decubito (letto-teli)		Trasferimento letto-barella (letto-barella-tavola)	
Manuale (n°=64)	Ausiliato (n°=64)	Manuale (n°=51)	Ausiliato (n°52)	Manuale (n°=64)	Ausiliato (n°=64)
6,5 (5,0-9,5)	2.5 (0,1-5,0)	5.0 (4,0-8,5)	3,1 (0-5,0)	7,0 (5,0-9,5)	1,5 (0,5-4,0)

Tabella IV. ***Risultati VR da MMP effettuata nel 2012-13 nei diversi settori***

UU.OO. TOTALI	Alto Rischio		Medio Rischio		Basso Rischio		Rischio assente	
N°=131	N°	%	N°	%	N°	%	N°	%
REPARTI	8	22,8	12	34,3	12	34,3	3	8,6
BLOCCHI	6	75	0	0	1	12,5	1	12,5
SERVIZI	14	15,9	9	10,2	15	17	50	56,8
Totale	28	**21,4**	21	**16**	28	21,4	54	41

Tabella V. ***Percentuale di lavoratori esposti per livello di rischio nei diversi settori***

UU.OO. TOTALI	Alto Rischio		Medio Rischio		Basso Rischio		Rischio assente	
N°=131	N°	%	N°	%	N°	%	N°	%
REPARTI	188	24,2	217	27,9	226	29,1	145	18,7
BLOCCHI	177	91	0		13	6,7	4	2,2
SERVIZI	190	30,9	72	11,7	97	15,8	256	41,6
Totale operatori	555	**35**	289	**18,2**	336	21,2	405	25,6

sponde ad una criticità ben nota negli ospedali, ovvero la difficoltà a mantenere le carrozzine nella unità operativa di appartenenza. Nella Tabella VI emerge anche un notevole investimento economico effettuato dall'azienda nel periodo 2012-2016 (pari a circa 958.000 euro).

Nei primi tre anni di formazione (2013-2016) erano stati raggiunti il 62% dei lavoratori esposti e circa 80% dei coordinatori infermieristici, permanevano quindi da formare il 38% degli operatori.

I criteri utilizzati per identificare una stima dell'efficacia delle strategie preventive condotte sono riconducibili alla riduzione del livello di esposizione delle aree precedentemente ad alto rischio; in particolare alta efficacia si identifica qualora da alto livello si passi a livello trascurabile mentre media efficacia qualora da alto livello si passi a medio.

In Figura 2 vengono presentati i dati aggregati delle 22 UU.OO. analizzate per la stima di efficacia.

Figura 2. ***Valutazione di efficacia nelle 22 UU.OO. analizzate***

Tabella VI. ***Riepilogo delle attrezzature fornite nelle diverse UU.OO. nel periodo 2012-2016***

ATTREZZATURE ACQUISITE NEL PERIODO DAL 2012 AL 2016			
TIPOLOGIA ATTREZZATURE	**RICHIESTE**	**ACQUISITE**	**%**
LETTI ERGONOMICI	529	416	79%
SOLLEVATORI ERGONOMICI	14	11	79%
SET DI TELI ALTO SCORRIMENTO	122	69	57%
TAVOLA ALTO SCORRIMENTO	70	44	63%
CARROZZINE ERGONOMICHE	30	72	+
BARELLE ERGONOMICHE	52	52	100%
POLTRONA PRELIEVI ERGONOMICHE	10	10	100%
LETTINI VISITA AMBULATORIALI ERGONOMICI	24	9	37.5%
LETTINI GINECOLOGICI ERGONOMICI	3	3	100%
LETTINI FISIOKINESITERAPIA ERGONOMICI	3	2	67%
Complessivamente, nel periodo 2012-2016 sono stati investiti circa 958.000 Euro.			

Nel periodo 2014-2019, complessivamente, rispetto agli operatori esposti a rischio da MMP rilevati durante la valutazione del rischio del 2013 (n° 1.180), la formazione è stata somministrata al 98%.

La proposta avanzata nel 2017 di formare un gruppo di ergoformatori, dopo una prima fase di condivisione e relativa costituzione di una delibera, è stata abbandonata per carenza di personale.

Nelle UU.OO. valutate nel 2019 (n° 26) si evidenzia comunque una riduzione del livello di esposizione nel 46% dei casi, mentre nel 35% il livello di rischio è rimasto invariato e nel 8% è peggiorato in quanto sono aumentati i pazienti non autosufficienti (NA).

Ulteriore risultato ottenuto nelle 26 UU.OO. riguarda la percentuale di utilizzo delle attrezzature: il 79% utilizzava le attrezzature, soprattutto per sollevamenti di pazienti non collaboranti (NC), da sollevare totalmente, o per pazienti obesi. Permanevano comunque alcuni compiti manuali spesso sovraccaricanti.

4. Conclusione

Tutti gli interventi messi in atto, anche se con difficoltà, hanno portato a dei buoni risultati, in termini di fornitura attrezzature, formazione del personale e riduzione del rischio specifico da MMP come si è potuto vedere dalle tabelle precedenti.

Sebbene sia mancato un riconoscimento formale dell'ergoformatore presente in azienda, egli ha potuto effettuare tutte le attività e le strategie messe in atto, che hanno consentito una attiva e continua collaborazione tra i diversi servizi aziendali deputati alla complessiva valutazione del rischio (SPP) e alla definizione del capitolato per l'acquisizione di ausili/attrezzature (Ufficio approvvigionamento, Ufficio Infermieristico, Ingegneria clinica).

Ulteriore conferma del riconoscimento informale è avvenuta da parte del personale formato (operatori e coordinatori) che ha mantenuto i contatti con l'ergoformatore per tutte le necessità specifiche.

Per mantenere i risultati della formazione effettuata, dell'utilizzo delle attrezzature fornite, ripristinare/fornire le attrezzature mancanti e controllare l'efficacia nel tempo, le conclusioni a cui si è giunti sono sovrapponibili a quelle raccomandate a livello internazionale, ovvero costituire un gruppo di ergoformatori / ergocoach.

Tali risorse interne, provenienti dalle differenti UU.OO., dovranno dedicare parte del tempo lavorato a questa attività (almeno 4 ore a settimana) e avranno un regolare riconoscimento da parte del management aziendale.

Il gruppo di ergoformatori ha come obiettivo principale la riduzione dei disturbi muscoloscheletrici e degli infortuni degli operatori sanitari (causati da sovraccarico biomeccanico) e migliorare la qualità dell'assistenza erogata. Gli obiettivi sopra citati sono raggiungibili con maggiore facilità (soprattutto all'interno di una grande azienda ospedaliera) attraverso un supervisore degli ergocoach, figura che coordina il gruppo di ergocoach e pianifica gli interventi da attuare per ridurre le occasioni di aumento del sovraccarico biomeccanico, garantendo l'appropriatezza delle attrezzature da destinare alle singole realtà lavorative in relazione ai bisogni. Tutto ciò attraverso un'analisi della valutazione del rischio specifico, e una formazione dedicata per gli ergoformatori delle singole UU.OO.

Questa figura inoltre supporta lo svolgimento delle specifiche attività, subentra quando si presentano particolari problemi nelle diverse UU.OO. di difficile gestione e programma degli incontri con il gruppo di ergoformatori (mediamente ogni 3 mesi) per confronto e condivisione delle problematiche da affrontare. È deputato inoltre a stilare le caratteristiche ergonomiche delle attrezzature da acquisire, partecipa alla stesura dei capitolati d'acquisto, valuta in sede di commissione di gara che le caratteristiche ergonomiche richieste corrispondano ai prodotti offerti. È di fondamentale importanza la sua collaborazione con gli altri professionisti nella gestione del rischio (RLS, RSPP), con l'ufficio approvvigionamenti, con la direzione delle professioni sanitarie non mediche, con la direzione sanitaria, con il medico competente, con l'ingegneria clinica per quanto di competenza e con tutte le figure che coordinano il personale addetto ad effettuare la movimentazione manuale dei pazienti (coordinatori infermieristici). Egli si occupa anche di effettuare indagini di mercato sulla ricerca di attrezzature necessarie a rispondere a specifici bisogni aziendali.

In sintesi l'attuazione di tale proposta, consentirebbe:

- riduzione del rischio specifico (rischio da movimentazione pazienti) per i lavoratori addetti all'attività di assistenza;
- utilizzo reale delle attrezzature/ausili forniti con aumento di sicurezza/comfort per il paziente, oltre ad un recupero dei costi inerenti la dotazione di attrezzature fornite ma non utilizzate;
- riduzione assenze per malattia per disturbi muscoloscheletrici (e relativa riduzione dei costi indiretti);
- implementazione di un programma di "invecchiamento attivo" per recuperare esperienza e professionalità in operatori del comparto;
- migliorare lo stato di salute per i lavoratori esposti al rischio da movimentazione pazienti;
- supporto per il medico competente nella gestione dei soggetti con limitazioni o prescrizioni;
- fornitura al coordinatore infermieristico di strumenti ed attrezzature per meglio gestire i turni di lavoro in relazione ai soggetti affetti da problematiche muscoloscheletriche.

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Music listening for people living with dementia: a systematic review

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ABSTRACT. **Introduction.** ***This review aimed at exploring how music listening-based approach can be effective on physiological, cognitive and behavioural aspects, with specific reference to the domain of dementias. Music listening can be considered one of the most common approaches in dementia care, frequently in combination with other non-pharmacological treatments. This type of intervention may allow persons with dementia to work on the organization and regulation of their emotions thanks to the mediation of the sonorous-musical element.***
Methods. ***Two independent researchers performed literature search by consulting the PUBMED database and the Cochrane Register of randomized controlled trials (articles written in English and published from January 1st 2000 to February 28th 2022 were considered as eligible).***
Results. ***Twelve articles met the inclusion criteria and were included in this review. The selected studies highlighted some effects of music listening in people with moderate to severe dementia. Assuming a clinical point of view, the results showed how music listening intervention could bring benefits on the behavioural and psychological symptoms of dementia, also if not always statistically significant.***
Discussion/Conclusion. ***The study focused on the need to define clear criteria of music listening programs selection and administration, but also on the involvement of trained music therapists in planning and managing the music listening-based interventions. Music listening interventions should be developed by implementing evidence-based practice and integrating research in the field. The identification of specific musical elements connected with the therapeutic outcome is a key point for the music therapy future.***

Key words: *Dementia, Behavioural Disturbances, Music Therapy, Music Listening, Evidence-Based Approaches.*

RIASSUNTO. ***Introduzione.*** **L'articolo si pone l'obiettivo di esplorare come l'ascolto musicale possa rivelarsi efficace a livello fisiologico, comportamentale e cognitivo, nel contesto dell'invecchiamento patologico. L'ascolto musicale si può infatti considerare uno degli approcci più utilizzati nella cura di persone con demenza, frequentemente in combinazione con altri trattamenti di tipo non farmacologico. L'elemento sonoro-musicale può infatti contribuire a migliorare l'organizzazione e la regolazione emotivo-affettiva.**
Metodi. **Due ricercatori indipendenti hanno condotto una ricerca della letteratura scientifica presente in quest'ambito, consultando PUBMED e il registro Cochrane degli studi controllati randomizzati (sono stati considerati eleggibili gli articoli scritti in lingua inglese e pubblicati tra il 1° Gennaio 2000 e il 28 Febbraio 2022).**

Introduction

The symptoms that people with dementia have to live with concern both aspects related to behavioral disorders and to psychological ones (Behavioral and Psychological Symptoms of Dementia). The difficulties they face affect the patients themselves but also their caregivers, whose burden is often debilitating.

The adoption of non-pharmacological therapies may be helpful in the reduction of the symptoms that cannot be treated with pharmacological therapies.

The results of previous studies have shown evidence of how music therapy may contribute in the reduction of these symptoms in patients who are going through the moderate and more advanced stages (Van der Steen et al., 2018).

Music listening is one of the most common approaches to the use of music in people with dementia. The scientific literature has shown the important emotional and behavioural effects of listening to music, in particular as far as depressive symptoms, anxiety and agitation are concerned (Gaviola et al., 2020; Soufineyestani et al., 2021; Van der Steen et al., 2018) and, more broadly, a general improvement in the Quality of Life (Moreno-Morales et al., 2020). However, when music listening is employed as a therapy it is not yet completely clear which are the musical factors that may produce a therapeutic effect.

Gerdner (2000, 2005) introduced the use of individualized listening (based on preferred music) as the main intervention technique in dementia and, later, Gerdner (2012) suggested an application protocol to guide music therapists and/or caregivers in the creation of music listening programs. From a practical point of view, however, there are still no defined guidelines for therapeutic music listening in dementia. The present review aims to analyse and comment on the more recent randomized controlled studies that have so far been carried out in the field of dementia care and makes a number of recommendations for the future development of this technique.

Methods

The literature search was conducted by two independent researchers in the PUBMED database and the

Risultati. **Tra gli articoli analizzati, dodici lavori risultano coerenti con i criteri di inclusione stabiliti e, pertanto, sono stati inclusi nella revisione. Gli studi presi in considerazione hanno permesso di sottolineare alcuni effetti dell'ascolto musicale in persone con demenza di livello moderato-severo. Da un punto di vista clinico i risultati, anche se non sempre statisticamente significativi, hanno mostrato come un intervento basato sull'ascolto musicale può apportare dei benefici soprattutto sui sintomi comportamentali e psicologici della demenza.**

Discussione/Conclusione. **Questo studio ha permesso focalizzare l'attenzione sia sul bisogno di definire criteri sistematici nella scelta e nella proposta di programmi di ascolto, sia sulla necessità di coinvolgere musicoterapeuti formati nella creazione, pianificazione e gestione degli interventi basati sull'ascolto musicale. Questi interventi dovrebbero, inoltre, considerare le evidenze scientifiche presenti in letteratura e costituire essi stessi integrazioni alla ricerca in questo ambito. Un punto chiave da tenere in considerazione per il futuro dell'ascolto musicale terapeutico riguarda, infine, l'identificazione di specifici parametri strutturali della musica finalizzati a ottenere uno specifico effetto terapeutico.**

Parole chiave: Demenza, Disturbi comportamentali, Musicoterapia, Ascolto Musicale, Approcci Evidence-Based.

Cochrane Register of randomized controlled trials (RCTs). The review included RCTs (in English and containing a clear reference to music listening treatments for people with a certain diagnosis of dementia), published between January 1st 2000 and February 28th 2021.

The following keywords were used for the search: "music listening", "recorded music", "individualized music listening", "personalized music", "receptive music", in addition to "dementia" or "Alzheimer".

Results

The Flow Chart of the study shows the process of selection of the studies included in this review (Fig. 1). In their Randomized Controlled Trial study, D'Aniello et al. (2021) proposed an application of the above mentioned protocol designed by Gerdner (2012). The sample consisted of 60 people with moderate- to- severe dementia and their associated caregivers. The participants were randomly assigned to one of the two planned groups, either the experimental group or the control one, in order to have two groups of 30 people each. In the Control Group patients received Standard Care while for the Experimental Group a Music Listening intervention based on Gerdner's indications was provided. The intervention was scheduled for 8 weeks with two half-hours weekly meetings and the effectiveness was assessed through the completion by caregivers of the Neuropsychiatric Inventory and the Caregiver Burden Inventory. The results showed a significant reduction both in neuropsychiatric symptoms and in the caregivers' burden scores in the group that benefited from the Music Listening intervention compared to the Standard Care group.

Kwak et al. (2020) conducted a crossover RCT study, in order to evaluate the outcomes of agitation, behavioral symptoms and the use of psychotropic medications in 59 people with dementia. A Music & Memory intervention was carried out over a 14-week period and its effectiveness was evaluated. Patients were randomized into two groups and they received the same treatments of Music and No music, each lasting six weeks, separated by two weeks of washout. The musical treatment was run by staff trained in the Music & Memory program; playlists of the patients' meaningful and favorite music were created and recorded on an iPod. Patients listening time was flexible and it was monitored through the data collected by each iPod. There were no significant effects in either condition over time both in the Cohen-Mansfield Agitation Inventory total score and in the use of psychotropic medications. Otherwise, for Neuropsychiatric Inventory score a significant increase in depression emerged over time in Condition 1 (Music first) and a significant decrease in Condition 2 (Music last).

Maseda et al. (2018) performed a RCT recruiting 21 patients with diagnosis of severe dementia, randomly assigned to the individualized music listening group (listening to preferred music) or to multisensory sessions group, in a Snoezelen room. Patients underwent 24 bi-weekly sessions conducted by psychologists or occupational therapists.

Therapists selected the music taking into account the participants' preferences. The aim of the study was to explore the effects of two non-pharmacological interventions on mood, behaviour and biomedical parameters. Both groups had immediate positive effects on mood and behaviours. The multisensory group performed a better visual follow-up of the stimuli, while the music listening group was more relaxed and happier. In both groups, participants showed a decrease in Heart Rate and an increase in Oxygen Saturation values after the sessions.

Valdiglesias et al. (2017) carried out a study to verify whether an individualized music listening intervention rather than a multisensory stimulation environment in a Snoezelen room produce changes in Salivary Chromogranin A (sCgA) level in patients with dementia. Twenty-two patients with severe dementia were randomly assigned to the multisensory stimulation environment group or the individualized music listening group. The treatments were based on 32 bi-weekly sessions. The stress level was evaluated by determining sCgA concentration in saliva samples collected immediately before and after each session. There were no significant differences in the sCgA levels between groups.

Sakamoto et al. (2013) investigated the effects of different individualized music interventions for patients with severe Alzheimer's disease. Thirty-nine patients were randomly assigned to two music intervention groups (music listening or interactive activities combined with music listening) or to a no-music control group and the intervention period lasted 10 weekly sessions. Behavioral and physiological assessment was made in the study. The short-term effects showed a dominant parasympathetic nerve activity after music interventions, a significantly more comfortable mood in the music listening group and a greater improvement of emotional state in the active group com-

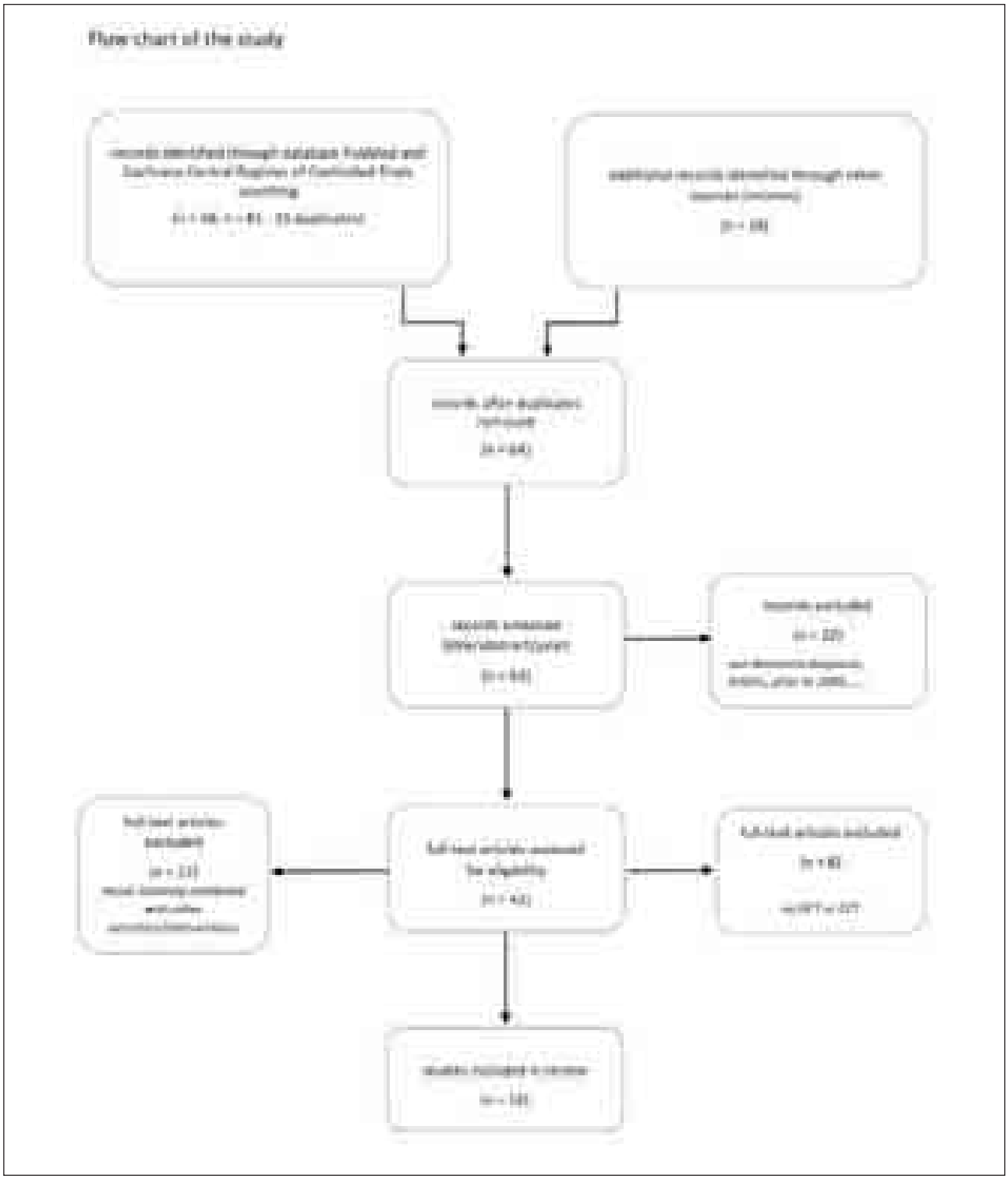

Figure 1

pared to the other groups. Long-term effects showed a greater improvement of behavioral disturbances in the active group compared to music listening and no music groups.

Cheung et al. (2018) enrolled 165 patients with dementia in a multicenter RCT study to examine the effects of three different activities (music-with-movement, preferred music listening and social activity) on cognitive functions and psychological symptoms. The interventions (12 bi-weekly sessions) were carried out by two independent and trained research assistants. Psychological and cognitive outcomes were evaluated. While the improvements in the Music listening group were limited to global cognition and anxiety, Music-with movement group improved in global cognition, memory, anxiety and depression. No significant results were found in the social activity group and no significant differences between groups were observed.

Cheung et al. (2020) in a further RCT study, examined the same number of patients, allocated in similar three intervention groups (music-with-movement, preferred music listening and social activity), with the intention of verifying the level of agitation after the bi-weekly treatment, lasting 30/45 minutes, for 6 weeks. There were no significant differences between groups: in fact, all three types of intervention showed a significant reduction in agitation from baseline to post-intervention, although the music-with-movement treatment showed better results.

Sánchez et al. (2016) performed a study that involved 22 institutionalized patients with dementia. The study compared the effects of a multisensory stimulation environment and an individualized music listening approach on agitation, emotional and cognitive status and dementia severity. The patients were undergone 32 bi-weekly sessions conducted by psychologists or occupational therapists. A behavioral, cognitive and functional assessment was made in the study. There was an improvement in agitation for both groups, while in anxiety and dementia severity only the multisensory stimulation environment group improved during the treatment.

Raglio et al. (2015) evaluated the effects of active music therapy and individualized listening to music on 120 people with behavioral and psychological symptoms of dementia, assigning them randomly to one of the following three treatments: Active Music Therapy plus Standard Care, Individualized listening to music (preferred music, chosen with the help of a music therapist) plus Standard Care and Standard Care only. The treatments were held twice a week for 10 weeks and music therapists conducted the music sessions. Functional, cognitive and behavioral evaluations were performed in the study. All groups showed a reduction of behavioral disturbance and improved in quality of life. No significant differences were found between groups.

The study by Särkämö et al. (2014) investigated the effects of everyday musical activities (singing or regular music listening) conducted by caregivers in patients with mild-moderate dementia. Eighty nine patients-caregivers dyads were randomized to a singing group, music listening group (whose playlist was based on the individual musical preferences) or to a usual care control group. The study showed that the music interventions improved the cognitive performances, especially attention and executive functions. Music groups improved also in quality of life. Moreover, a change in the psychological stress and burden of the family members was observed in all groups, with effects lasting longer in the singing group compared to music listening group.

Arroyo-Anlló et al. (2013) investigated the impact of familiar music on self-consciousness in 40 patients with Alzheimer's disease. Patients were allocated in the experimental group (listening to familiar songs) and the control group (listening to not familiar songs). Family caregivers administered 36 three-weekly sessions of music listening. Cognitive and psychological evaluations were made in the study. The patients who received a familiar music intervention showed a stabilization or improvement in aspects of self consciousness. On the contrary, control group showed a deterioration of most of the self consciousness aspects after unfamiliar music stimulation, except the self consciousness aspects of body representation and affective state.

Guétin et al. (2009) enrolled 30 mild-to-moderate patients with Alzheimer's disease to study the effect of music therapy based on a specific music listening approach on anxiety and depression. The experimental group underwent 16 weekly sessions, while the control group underwent the same number of reading sessions. The music therapy group showed significant improvements in anxiety and depression compared to the control group.

Details related to studies results are summarized in Table I.

Discussion

This review selected a limited number of RCTs dealing with the use of music listening in dementia, this being a frequently used approach in music therapy (Kern & Tague, 2017).

The studies examined display a number of weaknesses. The samples numbers are small. The authors often fail to describe the rationale of their study other than by referring to listening to familiar or preferred music by patients. Regarding music preferences, moreover, it remains unclear how a given listening program relates to a specific therapeutic objective (e.g. the reduction of a behaviour disorder or the overall activation of the person). It emerges, in fact, that the musical preferences of the patient with dementia frequently derive from interviews with family members and/or are mediated by those who propose the listening intervention, without reference to a specific therapeutic objective. It is further to be noted that application protocols are conspicuous by their absence in these studies. The notable exception is the work of Guétin et al. (2009), aimed at the reduction of anxiety and depression, which proposes a "U" model in which the musical pieces follow a sequence of gradual reduction of musical parameters until a level of maximum relaxation is reached, followed by a partial recovery of the activation level. The authors describe the intervention protocol but not its therapeutic rationale.

Another notable absence in the studies is the figure of the music therapist. There are some exceptions (Guétin et al., 2009; Raglio et al., 2015; Särkämö et al., 2014), in which the therapist has at least the role of choosing the pieces to be played. Music listening intervention in these studies is not therapist-led but involves situations in which the patient listens to the playlists independently, without a healthcare professional present. This point requires elucidations too, given that people with severe dementia rarely have sufficient autonomy to be able to listen to music without any support.

From the clinical point of view, the study findings show that listening to music brings some benefits on the physiological, cognitive and behavioral levels.

On the whole, however, the results do not constitute clear evidence or reach significance. The exceptions are

Table 1. *Main results of the study*

Author(s)/Year	Study Population	Types of Intervention/Duration	Intervention characteristics	Assessment	Results
D'Aniello et al., 2021	60 people with moderate-to-severe dementia and associated caregivers	ML (n=30) SC (n=30) Bi-weekly sessions/30 minutes /8 weeks	Music listening intervention based on patients' preferences respecting Gerdner and colleagues' protocol	Psychological/neurological examination at baseline (MMSE included) BDI-II, PSWQ used prior to the intervention, NPI (mainly frequency for severity, NPI_aXb and distress, NPI_distress) and CBI for caregivers before and after the intervention	Time X Group effect found in CBI scores (p = 0.006) showing a significant reduction in caregivers' burden scores after the intervention for the Music Listening group Time X Group effect found in NPI_frequencyXseverity and NPI-distress scores (p = 0.001), with greater effect found for the Music Listening group
Cheung et al., 2020	165 People with any type of dementia	MM group (n=58) ML group (n= 54) SA group (social chatting) (n=53) Bi-weekly sessions/30-45 minutes/6 weeks	Music listening based on patients' preferences (family relatives' interviews): mainly popular music from 1940s to 1970s	CMAI-NH at baseline, after 6 week (T1) and at follow-up (3 months after the end of treatment)	No significant differences between groups in reducing agitation Significant reductions of CMAI-NH total (p < .001) and subscores (p < .001) within group Significant reduction from baseline to T1 in all groups: MM (p < .001), ML (p < .001), SA (p = .007)
Kwak et al., 2020	59 People with dementia or Alzheimer's disease	Condition 1 (n=30) Condition 2 (n=29) 14 weeks (condition 1: M&M for 6 weeks, 2 weeks washout, no music for 6 weeks; condition 2: no music for 6 weeks, 2 weeks washout, M&M for 6 weeks)	Music listening based on individual's preferences or songs significant to person's life experience, music popular from childhood to adulthood listening time flexible (content, frequency and dosage delivered by staff time of usage recorded by an application in the iPod)	CDRS, Katz index DLD at baseline CMAI, NPI-NH, use of psychotropic medications at baseline, 6th week, after the 2-weeks washout, 8th and 14th weeks	No significant effects in both conditions by time in CMAI total score Significant effects for irritability and depression Condition 1 in phase 1 increase over time in irritability, decrease in Condition 2 In condition over time for NPI a significant increase in depression (NPI subitem) over time in Condition 1 and significant decrease in Condition 2 (p = .04) No significant effect on use of medication (data not shown)
Maseda et al., 2018	21 People with dementia (severe and very severe cognitive decline)	Individualized music group (n=11); MSSE group (Snoezelen room) (n=10) Bi-weekly sessions/30 minutes/12 weeks	Music listening (PC) based on patients' preferences (different types of Spanish music)	Finger pulse oximeters (HR and SpO_2), before/after sessions; IS (mood and behavior), immediately before/during and after and during sessions	No significant differences between groups MSSE and Music groups: Improvement in mood (IS, happy/content: p = .001/p = .013), relating to people (IS, related well: p = .023/p = .034), relating to environment (IS, more attentive/focused on environment/objects: p = .005/p = .007); decrease in HR (p = .013) and increase in SpO_2 values (p = .011) MSSE group: improvement in stimulation level (IS, enjoying themselves/active or alert: p = .017, Bored, inactive or sleeping inappropriately: p = .026, relaxed, content or sleeping appropriately: p = .021) Differences between groups (IS during) in tracking observable stimuli, MSSE group: observant (IS, p = .044), Music group: relaxed/content (IS, p = .003)

(segue)

Tabella I. *(segue)*

Author(s)/Year	Study Population	Types of Intervention/Duration	Intervention characteristics	Assessment	Results
Cheung et al., 2018	165 People with any type of dementia	MM group (n=58) ML group (n= 54) SA group (social chatting) (n=53) Bi-weekly sessions/duration not given/6 weeks	Music listening based on patients' preferences (family relatives' interviews)	RAID, GDS, MMSE, FOME, MVFT, DST at baseline, after 6 week and at follow-up (6 weeks after the end of treatment)	No significant differences between groups MM group: improvement in global cognition (MMSE: $p < .001$), memory (FOME total storage: $p < .001$; FOME delayed memory: (p .002); anxiety (RAID: $p < .001$) and depression (GDS: p .002) ML group: significant changes in global cognition (MMSE: $p = .003$) and anxiety (RAID: $p < .001$)
Valdiglesias et al., 2017	22 People with dementia (severe and very severe cognitive decline)	MMSE group (n=11); Music group (n=11) Bi-weekly sessions/30 minutes/16 weeks	Music listening based on patients' preferences	sCgA concentration in saliva samples (before/after each intervention), CMAI, RAID, SMMSE and BANS-S at pre-trial, mid-trial, post-trial and 2 months after the intervention (follow-up)	No significant differences in the sCgA levels in both groups and between groups Exploration of hypothetical existence of associations of agitation, anxiety, cognitive function and dementia severity with sCgA levels. No significant correlation found in any sampling time
Sánchez et al., 2016	22 People with dementia (severe and very severe cognitive decline)	MMSE group (n=11); Individualized music group (n=11) Bi-weekly sessions/30 minutes each/16 weeks	Music listening based on patients' preferences (different types of Spanish music)	CMAI, CSDD, RAID, SMMSE, BANS-S at baseline, after 8 weeks), at the end of treatment and at follow-up (after 8 weeks from the end of treatment)	Both groups improved in agitation (CMAI: $p = .031$) mood (during follow-up, CSDD: $p = .006$), anxiety (during follow-up, RAID: $p = .021$) MSSE group: improvement in the severity of dementia between pre-, mid- and post-intervention (BANS-S: $p = .007$) No significant differences between groups
Raglio et al., 2015	120 People with moderate to severe dementia and BPSDs	MT (plus Standard care n=40); LtM (plus SC, n=40), and SC (n=40) Bi-weekly sessions/30 minutes/10 weeks =	Music listening based on patients' preferences (PWD or and formal or informal caregivers' interviews)	CDR, MMSE, NPI, BI, CBS-QoL and CSDD before, after the treatment and 2 months after the end of treatment	All groups showed a reduction in behavioral disturbances (NPI global scores: $p = \leq .001$), depression (CSDD: $p = .001$), and quality of life (CBS-QoL: $p = .01$) No significant results were found between groups Addition of MT or LtM to SC didn't show significant effects on BPSDs
Särkämö et al., 2014	89 PWD-caregiver dyads (with mild-moderate dementia)	SG (n=30); MLG (n=29); CG (usual care, n=30) 10 Weekly sessions/1.5 hour each	Music listening based on the individual musical preferences of PWDs (Finnish popular music from the 1920s to 1960s)	Standard neuropsychological tests (MMSE), CBS, GHQ, QoL-AD, ZBI (before/after the intervention and 6 months later) +final short semi-structured interview at follow up 2	Music intervention groups: improvement of performance on tasks of general cognition (MMSE: $p = .041$), attention and executive function (MMSE: $p = .039$); significant long-term effects for orientation level (MMSE: $p = .005$); improvement in quality of life (CBS: $p = .001$) Significant long-term effect in SG compared to MLG (ZBI: $p = .029$)

(segue)

Tabella I. *(segue)*

Author(s)/Year	Study Population	Types of Intervention/Duration	Intervention characteristics	Assessment	Results
Sakamoto et al., 2013	39 people with severe Alzheimer's type dementia	Control group (n=13); Passive group (listening to selected music through CD player) (n=13); Interactive group (listening to music and interactive activities, like clapping, singing, and dancing) (n=13) Weekly sessions/30 minutes/10 weeks	Music listening based on patients' preferences and related to special memories	MMSE, CDRS at baseline Short-term effects (indices of BPSD influencing emotion and stress levels): autonomic nerve index and FACES Scale before/after session Long-term effects: BEHAVE-AD to evaluate changes in BPSDs, 2 weeks before/after 10 music sessions/3 weeks after the end of the intervention HR and HRV (HF), before/after session	Passive and Interactive groups: dominant parasympathetic nerve activity after intervention in (HR: $p < .01$; HRV(HF) = $p < .01$); significant increase in BPSD ($p < .025$) 3 weeks after music intervention Passive group: more comfortable mood (Faces Scale: $p < .01$); improvement in affective disturbance and anxieties and phobias (BEHAVE-AD: $p = .02$) Interactive group: improvement in emotional state (Faces Scale: $p < .01$); improvement in affective disturbance (BEHAVE-AD: $p = .02$), anxieties and phobias (BEHAVE-AD: $p = .01$), paranoid and delusional ideation (BEHAVE-AD: $p = .01$), aggressiveness (BEHAVE-AD: $p = .01$), and activity disturbance (BEHAVE-AD: $p = .01$); reduction of caregiver burden (BEHAVE-AD global rating: $p = .01$)
Arroyo-Anlló et al., 2010	40 People with diagnosis of probable Alzheimer's disease	Experimental AD group (familiar songs, n=20); Control AD group (not familiar songs, n=20) Three times a week/2-4 min/ 12 weeks	Music listening was chosen from online Spanish traditional music databases, self-selected for Experimental group (familiar music) and based on the researchers' proposals for Control group (not familiar music)	MMSE, FAS, SC-questionnaire, 1-2 weeks pre/post interventions	Experimental AD group: improvement in SC questionnaire sub-items: Personal identity ($p = .023$), Affective state ($p = .031$), Moral judgements ($p = .037$), Body's representation ($p = .049$) Comparisons between groups: significant pre/ post-intervention difference in the total scores of the SC questionnaire ($p = 0.016$) Significant differences in SC questionnaire subitems: Personal identity ($p = .019$), Anosognosia ($p = .042$), Affective state ($p = .02$), Prospective memory ($p = .04$), Moral judgements ($p = .034$) Control AD group: Significant increase in impairment for the total SC score in control group ($p = 0.038$) Significant worsening in cognitive functions (MMSE: $p = .038$; FAS: $p = .009$)
Guétin et al., 2009	30 People with moderate stages of AD	Intervention group (individual receptive music therapy, n=15); Control group (reading sessions, n=15) Weekly/20 minutes/16 weeks	The music based on the patients' personal tastes after an interview/questionnaire (through headphones and wearing a mask to minimize visual interference) The validated "U" technique was employed (from stimulating to slow and moderate rhythm)	MMSE at baseline, HRSD, GDS at 0/4/8/16/24 weeks	Significant differences between groups in anxiety and depression Music therapy group: significant improvements in anxiety ($p < .01$) and depression ($p < .01$) from week 4 to the follow-up (week 24) ($p < .01$)

AD= Alzheimer's Disease; BANS-S= Bedford Alzheimer Nursing Severity Scale; BDI-II= Beck Depression Inventory-II; BEHAVE-AD= Behavioral Pathology in Alzheimer's Disease; BI= Barthel Index; BPSD= Behavioral and Psychological Symptoms of Dementia; CBI=Caregiver Burden Inventory; CBS= Cornell-Brown Scale for Quality of Life in Dementia; CBS-QoL= Cornell Brown Scale—Quality of Life; CDR= Clinical Dementia Rating; CG= Control Group; CMAI= Cohen-Mansfield Agitation Inventory; CMAI-NH= Cohen-Mansfield Agitation Inventory-Nursing Home; CSDD= Cornell Scale for Depression in Dementia; DST= Digit Span Test; FAS= Frontal Assessment Short test; FOME= Fuld's Object Memory Evaluation; GDS= Geriatric Depression Scale; GHQ= General Health Questionnaire; HF= High-Frequency (component of HRV); HR= Heart Rate; HRSD= Hamilton Rating Scale for Depression; HRV= Heart Rate Variability; IS= Interact Scale (for Mood and behavior); Katz index DLD= Daily Living Dependence; LtM= Listening to Music; ML= Music Listening; MLG= Music Listening Group; MM= Music-with-Movement; MMSE= Mini-Mental State Examination; MSSE= Multisensory Stimulation Environment; MT= Active Music Therapy; MVFT= Modified Fuld Verbal Fluency; NPI= Neuropsychiatric Inventory; NPI-NH= Neuropsychiatric Inventory- Nursing Home; PSWQ= Penn State Worry Questionnaire; PWD= People With Dementia; QoL-AD= Quality of Life in Alzheimer's Disease; RAID= Rating Anxiety in Dementia; SA= Social Activity; SC= Standard Care; SC questionnaire= Self-Consciousness questionnaire; sCgA= Salivary Chromogranin A; SG= Singing Group; SMMSE= Severe Mini-Mental State Examination (in Sanchez); SpO2= Oxygen Saturation; ZBI= Zarit Burden Interview

the findings of Guétin et al. (2009), Arroyo-Anlló et al. (2013), Sakamoto et al. (2013) and D'Aniello et al. (2021). The study of Särkämö et al. (2014) evaluated the effects of several music interventions, including the approach based on musical listening and found evidence of an effect but the variety of interventions makes it difficult to attribute the effect to music listening alone.

The review highlights a number of issues. Firstly, the musical content on which listening is based needs to be defined in detail and in step with the therapeutic objectives. The criteria for compiling playlists also need to be defined and the procedures specified, i.e. the criteria for the inclusion of patients, the therapeutic objectives, the type of listening, the methods of proposal and verification of the intervention. It is difficult to imagine patients with dementia being able to suggest listening pieces to the music therapist on the basis of their musical tastes. As with musical content, it is necessary to identify which parameters of patients' preferred music correlate with the therapeutic need. The mere musical preference and the resulting pleasure in listening cannot be considered the only factor that acts therapeutically. The creation of therapeutic playlists is rather the product of several factors, subjective (preferences) and musical (parametric and structural characteristics of the pieces). (Raglio et al., 2018). Compiling playlists therefore requires a specific music therapeutic competence and the supervision of a professional in this field. Finally, the role of formal and informal caregivers is extremely important. People with dementia frequently present behavioural disorders and a lack of autonomy, making it difficult to implement listening programs at all. The caregiver's support is a key factor in the management of such programs and in the qualitative-quantitative evaluation of their effects (Gerdner & Schoenfelder, 2010).

Recommendations

In light of our analysis, we would make the following recommendations. A music therapy professional should always be present and active in the application of therapeutic music listening.

On the basis of musical, psychological and neuroscientific knowledge, the therapist will define an appropriate listening program, which should take into account not only the musical identity of the person but also the parametric and structural characteristics of music pieces and use them as a tool for pursuing certain therapeutic objectives (Raglio et al., 2018).

It is also important to establish a clear application plan, which details when and how the person should listen to the music, giving continuity and regularity to the intervention. The use of well-defined criteria for the evaluation of outcomes is a fundamental aspect of the therapeutic intervention (Raglio & Gianelli, 2009).

Further research is needed to define the musical contents used in order to create a link between the listening program and the desired therapeutic outcome.

Furthermore, it is essential to identify the target group of patients with dementia best responding to musical stimulation based on therapeutic listening, with particular reference to the type of dementia and the level of severity. Recent machine learning techniques could be a valuable support in identifying the factors predictive of success in a proposed intervention (Raglio et al., 2020). Finally, it could be useful to carry out more studies aiming at comparing the effectiveness of active music therapy with therapeutic music listening (Raglio et al., 2012).

Conclusion

Music listening can be a valid therapeutic support for people with dementia. This technique can be developed by taking into account the factors identified in our analysis, implementing evidence-based practice and integrating research in the field. The identification of specific musical elements related to the achievement of the therapeutic outcome is fundamental to the scientific approach to music therapy. Future studies that build on the points we have highlighted will hopefully strengthen existing clinical evidence on music listening in dementia.

Declaration of Conflicting Interests

The Authors declares that there is no conflict of interest.

Consent Statement

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Ethical Approval

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Letter to the editor

Is abestos exposure a risk factor for small airways obstruction?

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To the editor,

during these pandemic years, COVID-19 is taking away focus from other respiratory diseases such as pneumoconiosis, which should not be overlooked.

We would like to emphasize the possible role of small airways in subjects with asbestos exposure.

In a very interesting study, Yang et al (1) investigated the relation between increased small airway obstruction and asbestos exposure in patients with asbestosis. The authors evaluated lung function in a cohort of 281 patients with newly diagnosed asbestosis during an eight-year period, evidencing that patients with asbestosis have small airway obstructive defects that are significantly associated with asbestos exposure (1).

These results are very consistent and in line with our previous study, in which we showed that a population of 655 long-term residents in an environmental asbestos (tremolite)-exposed area had a higher prevalence of small-airways disease compared to a group of 653 individuals living in areas not tremolite-exposed (2). Odds Ratio for small-airways obstruction was 3.46, irrespective of smoking status (2).

To date, our knowledge on the role of small airways in pulmonary diseases is still matter of debate. Although small airways have a minor contribution to airway resistance in healthy subjects, it has been shown that small airways are the major site of airflow limitation in diseases such as asthma and Chronic Obstructive Pulmonary Disease (3).

Taken these data together, we warmly encourage clinicians and researchers to always consider small airways parameters when performing lung function on asbestos-exposed subjects. Moreover, long-term investigations are warranted to explore the decline in airflow over time in patients with either occupational or environmental asbestos exposure and with asbestosis.

Disclosure statement

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