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An innovative approach based on health surveillance for the prevention and early detection of cardiovascular diseases in a large cohort of healthcare workers

Luigi Vimercati[1,2]✉, Stefania Sponselli[1,2], Giuseppe Delvecchio[1,2], Gianmarco Giannelli[1,2], Antonio Caputi[1,2], Stefano Sole[1,2], Francesco Paolo Bianchi[3], Davide Traversa[4], Silvia Zagaria[1,2], Giampiero Bombini[1,2] & Luigi De Maria[1,2]

The aim of our three-year retrospective observational study on 6000 healthcare workers, all subjected to mandatory health surveillance, is to determine the risk factors and prevalence of cardiovascular diseases (CVDs) and to analyze the results of an ad hoc designated preventive health surveillance protocol. A risk assessment was performed and a preventive health surveillance protocol was implemented, including clinical-instrumental and laboratory tests aimed at the early detection of any sign of CVD. As a result, $n = 442$ new diagnoses of CVDs were made and the prevalence of CVDs increased from 12 to 16.1%. The higher prevalence was observed in physicians ($P = 57.8\%$; $p < 0.0001$). The main risk factors for CVDs were age, male sex and family history of CVDs. The analysis of CVDs determinants highlighted an unexpected protective role of shift work (aOR = 0.64; $p < 0.0001$). Our preventive health surveillance protocol allowed to reveal a high prevalence of undiagnosed CVDs, laying the foundations for future primary prevention and counseling interventions as part of the health promotion and TOTAL WORKER HEALTH programs. Further studies are needed to create solid scientific evidence that can guide public health decisions regarding new prevention models and health promotion programs also in the general population.

Keywords Cardiovascular diseases, Cardiovascular risk factors, Healthcare workers, Occupational risk, Prevention measures, Health surveillance

Cardiovascular diseases (CVDs) are a group of diseases affecting the heart and blood vessels and represent the main cause of death worldwide (about 30% of all deaths)[1]. CVDs include coronary heart disease (CHD), cerebrovascular disease, rheumatic heart disease, congenital heart disease, peripheral arterial disease, deep vein thrombosis and pulmonary embolism. Currently, the costs attributable to cardiovascular diseases in Europe are around 210 billion per year[2]. Among these, there are not only direct healthcare costs, but also indirect costs due to loss of productivity (e.g. absence from work due to illness or assistance).

Epidemiological cohorts during the early years have played an important role in clarifying the factors that predispose to cardiovascular disease and highlighting opportunities for prevention[3]. A crucial point of the risk-management strategy at the time was the ability to identify individuals most likely to have a future cardiovascular event, to enable the targeting of preventive interventions. These studies helped shed light on what we now refer to as "classic" cardiovascular "risk factors" including hypertension, dyslipidemia, diabetes, physical inactivity, smoking habits, alcohol intake, unhealthy diet, overweight and obesity[1,4–7].

The evolution of knowledge on the topic has led to the 2021 European Society of Cardiology (ESC) Guidelines on cardiovascular disease prevention in clinical practice. According to these guidelines, a systematic global cardiovascular risk (CVR) assessment is recommended in people with any major risk factors (class of

[1]Interdisciplinary Department of Medicine, University of Bari, 70124 Bari, Italy. [2]Occupational Medicine Unit, University Hospital of Bari, 70124 Bari, Italy. [3]Health Prevention Department, Local Health Authority of Brindisi, 72100 Brindisi, Italy. [4]Cardiology Unit, University Hospital of Bari, 70124 Bari, Italy. ✉email: luigi.vimercati@uniba.it

recommendation I, level of evidence C). Furthermore, it has been observed that a systematic evaluation of CVR in men over 40 years and/or in women over 50 years, without known CVR factors (CVRF), although not effective in reducing cardiovascular events and/or premature deaths, allows to obtain larger and earlier identification of CVRF. Therefore, this approach may be considered (class of recommendation IIb, level of evidence C), especially to increase the number of new diagnoses[5,8].

Despite these evidence and recent guidelines, it is still necessary to study and investigate these aspects in light of the unknown and new CVRF, which will constantly emerge and call into question the pre-established risk assessment and prevention models.

An example of this issue is represented by the recent SARS-CoV-2 pandemic and its interaction with the cardiovascular system. The recent knowledge acquired from scientific studies on the topic showed how subjects suffering from cardiovascular diseases are more at risk of severe outcomes from the COronaVIrus Disease 19 (COVID-19) pandemic and pre-existing cardiovascular diseases are important predictors of mortality from COVID-19[1,9]. An association was also observed between some cardiovascular risk factors (e.g. overweight and obesity) and Long COVID[9].

The lesson learned from the recent pandemic is that it would be important to implement such prevention and risk estimation models, in a modern "One Health" perspective, evaluating "classic", environmental and occupational CVRF at the same time[10].

In this regard, to date, several studies on traditional occupational risk factors highlighted a higher prevalence of CVRF in some categories of workers, including healthcare workers (HCWs) and shift workers[11–15]. Since most work settings have production/working cycles based on shift work, particularly healthcare ones, the development of workplace health promotion programs with a contemporary NIOSH TOTAL WORKER HEALTH approach is essential to prevent or minimize CVR in this category of workers[16]. Furthermore, as suggest by the 2016 ESC Guidelines on cardiovascular disease prevention in clinical practice, a cardiovascular screening of workers performing tasks at risk of third parties, such as HCWs, may be considered reasonable[6].

Recent literature lacks up-to-date large population studies on apparently healthy subjects regarding the incidence of cardiovascular diseases and the analysis of the cardiovascular risk profile through systematic and periodic clinical-instrumental investigations.

In this perspective, the aim of our retrospective observational study was to determine the risk factors and prevalence of CVDs among a large group of HCWs working in a University Hospital in the South of Italy and to analyze the results of an ad hoc designated preventive health surveillance protocol aimed at early diagnose CVDs.

Methods

Study design, setting and population

We carried out a retrospective observational study on the entire population of HCWs of the University Hospital (6000 HCWs), all subjected to health surveillance in accordance with Italian laws concerning the protection of workers exposed to occupational risks (D. Lgs. 81/2008), covering a three-year period (1 January 2020–31 December 2022).

The preventive protocol: risk assessment, variables of interest and data collection

A preventive health surveillance protocol was established by the Operative Unit of Occupational Medicine for all HCWs working at the University Hospital of Bari, Apulia, Southern Italy. As required by the protocol, during health surveillance medical visits performed according to Italian law concerning the protection of workers exposed to occupational risks (D. Lgs. 81/2008), all HCWs underwent a physical examination and a measurement of systolic blood pressure (SBP), diastolic blood pressure (DBP) heart rate (HR), height and weight for Body Mass Index (BMI) calculation. BP was measured according to American College of Cardiology/American Heart Association guideline for the prevention, detection, evaluation, and management of high BP in adults[17]. We used the traditional method of auscultation of the brachial artery with a stethoscope, in either the seated or the supine position, recording BP in both arms and using the arm with the higher reading for subsequent ≥ 2 readings. We used the average of ≥ 2 readings obtained on ≥ 2 occasions to estimate the worker's BP.

As part of health surveillance medical visits, family, physiological, occupational and pathological medical history were recorded in the health records of each HCW. Furthermore, at the same time, all workers underwent an electrocardiographic examination (ECG) and a blood sampling to evaluate plasma levels of total cholesterol (C-TOT; mg/dL), high-density lipoprotein cholesterol (HDL-C; mg/dL), low-density lipoprotein cholesterol (LDL-C; mg/dL), triglycerides (TG; mg/dL), glycemia (GLC; mg/dL), erythrocyte sedimentation rate (ESR; mm/h), C-reactive protein (C-RP; mg/L), as well as other routine blood indicators (e.g. indices of thyroid and renal function) performed according to the health surveillance protocol for healthcare workers exposed to occupational risk factors. The samples were analyzed at the hospital analysis laboratory using standardized methods and the normal ranges of these parameters were defined according to the sex and age of the worker and to the reference values established by international guidelines and literature data[18–23].

All workers were classified into four occupational categories, according to the Italian law on occupational risk assessment (D.Lgs 81/08) and to other studies conducted on the same cohort of workers[9,24–26]: physicians, nurses, other HCWs (e.g. biologists, psychologists, healthcare assistants, health technicians, midwives, physiotherapists, medical physicists, childcare workers, orthotists, technicians, students of health professions) and non-healthcare workers (e.g. administrative staff, auxiliary staff, cleaners, drivers, lawyers, librarians, chaplains, doormen, technical workers).

The main CVDs were classified into five categories: rhythm disorders (RD; e.g. tachyarrhythmia, bradyarrhythmia, conduction defects); anatomical-functional disorders (AFD; e.g. anatomical and/or kinetic alterations of the valve structures, of walls and/or cardiac chambers, chronic heart failure NYHA I-IV); ischemic disorders (ID; e.g. ischemic cardiomyopathy, ischemic stroke, stable angina, unstable angina); hypertensive disorders (HD; e.g. grade I, II, III arterial hypertension, isolated systolic hypertension, hypertensive heart disease); other CVDs (OD; e.g. endocarditis, myocarditis, pericarditis, other pericardial pathologies, pathologies of the large extracardiac vessels, peripheral arterial diseases).

Based on the results of the investigations, a risk assessment was carried out, defining HCWs at high risk (HR-HCWs) as subjects suffering from one or more of the following conditions: pathological history of CVDs (e.g. rhythm disorders, anatomical-functional disorders, ischemic disorders, hypertensive disorders, other cardiovascular diseases); alterations identified during the physical examination (PE) of the cardiovascular system (e.g. heart murmurs, rhythm alterations, pericardial rubs, blood pressure alterations); alterations in the ECG performed during the health surveillance examination (e.g. arrhythmias; alterations of the PR interval, QRS, T wave; conduction defects; alterations of ventricular repolarization); new onset of cardiological COVID-19 related symptoms (e.g. dyspnea, chest pain, palpitations, heart murmurs, pericardial rubs). In order to aim for the highest level of prevention, all deviations from normality, even those commonly interpreted as non-pathological (e.g. incomplete right bundle branch block) were considered worthy of further investigation with a specialist cardiological examination, and therefore "at high risk" in reference to our preventive protocol.

All the remaining HCWs were classified as low risk (LR-HCWs). For the latter, no further investigations were necessary and a periodic clinical reassessment was established, outside of data collection for this study. On the contrary, all HR-HCWs underwent a specialist cardiological examination and eventual further diagnostic-instrumental tests requested by the specialist (e.g. echocardiogram, transcranial color Doppler with bubble test, exercise stress test on a treadmill or cycle ergometer, 24-hour ECG recording, myocardial perfusion scintigraphy, cardiac magnetic resonance, coronary angiogram, hospitalization). In case of cardiological examinations negative for CVDs, HR-HCWs were subjected to periodic re-evaluation with a frequency established by the health surveillance protocol, outside of data collection for this study. In case of new onset and/or already known CVDs diagnosis, HR-HCWs were subjected to periodic re-evaluation with a higher frequency, established by the cardiologist.

The health surveillance protocol established by the Occupational Medicine Unit is summarized in the figure below (Fig. 1).

All HCWs were informed that data would be treated in an anonymous and collective way, with scientific methods and for scientific purposes, according to the principles of the Declaration of Helsinki.

Statistical analysis

The analysis was performed using Stata MP18 software. Continuous variables were expressed as mean ± standard deviation and range; categorical variables were expressed as proportions. The normality of the continuous variables was evaluated using the test of Skeweness and Kurtosis, although it was not possible to build a normalization model for those not normally distributed. Continuous variables were compared between multiple groups using the Kruskall–Wallis nonparametric test; categorical variables were compared between groups using the chi-square test or Fisher's exact test. Multivariable logistic regression was used to evaluate the association between total CVD diagnoses and the different determinants, as well as between new CVD diagnoses and the same determinants. The adjusted odds ratio (aOR) was calculated, with the 95% confidence interval (95% CI) indicated. The Pearson's chi-squared test was used to evaluate the goodness-of-fit of multivariate logistic regression models. For all tests, a *p-value* < 0.05 was considered statistically significant.

Statements

The patients were informed that data from the research protocol would be treated in an anonymous manner based on scientific methods and for scientific purposes in accordance with relevant guidelines and regulations and with the principles of the Helsinki Declaration.

Ethical approval was not necessary because all medical and instrumental examinations were performed according to Italian laws concerning the protection of workers exposed to occupational risks (D. Lgs. 81/2008). Nevertheless, the study was approved by the Ethics Committee of Azienda Ospedaliero-Universitaria Consorziale Policlinico of Bari (Parere Studio N. 7241).

Informed consent was obtained from all subjects involved in the study.

Results

Cardiovascular risk: frequency and distribution

From 1 January 2020 to 31 December 2022, we detected *n* = 1833 (30.5%) HR-HCWs: *n* = 701 (38.2%) male and *n* = 1132 (61.8%) female. Among these, there were *n* = 523 (28.5%) physicians (P), *n* = 514 (28%) nurses (N), *n* = 387 (21.1%) other HCWs (O) and *n* = 409 (22.3%) non-healthcare workers (NH). The characteristics of the HR-HCWs are reported in Table 1.

The male gender was more represented in the group of non-healthcare workers than in the group of nurses and other HCWs (NH = 49.6%; *N* = 27.8%; O = 31.5%). Physicians were younger than the other workers (average age: *P* = 41.4 years; NH = 56.4 years; O = 47.6 years; *N* = 47.2 years) and they also showed lower BMI values (average BMI = 23.7±3.8), higher values of protective HDL-C (*P* = 91.8%; O = 86.1%; *N* = 85.8%; NH = 79.2%) and a higher prevalence of physically activity (*P* = 38.4%; O = 25.6%; *N* = 23.2%; NH = 18.6%). The prevalence of smokers was higher in non-healthcare workers than in other categories, with a lower prevalence among physicians (*P* = 20.8%). Alcohol intake was higher among physicians (*P* = 54.7%). Musculoskeletal diseases were the most frequent comorbidities (*n* = 606; 33.1%), followed by thyroid diseases (*n* = 419; 22.9%), psychiatric diseases (*n* = 175; 9.6%) and diabetes mellitus (*n* = 100; 5.5%). Dyslipidemia was present in 46.9% of HR-HCWs, with a higher prevalence in non-healthcare workers (*n* = 254; 62.1%) compared to physicians (*n* = 179; 34.3%), nurses (*n* = 240; 46.7%) and other healthcare workers (*n* = 187; 48.3%). Among HR-HCWs, 55.4% were night

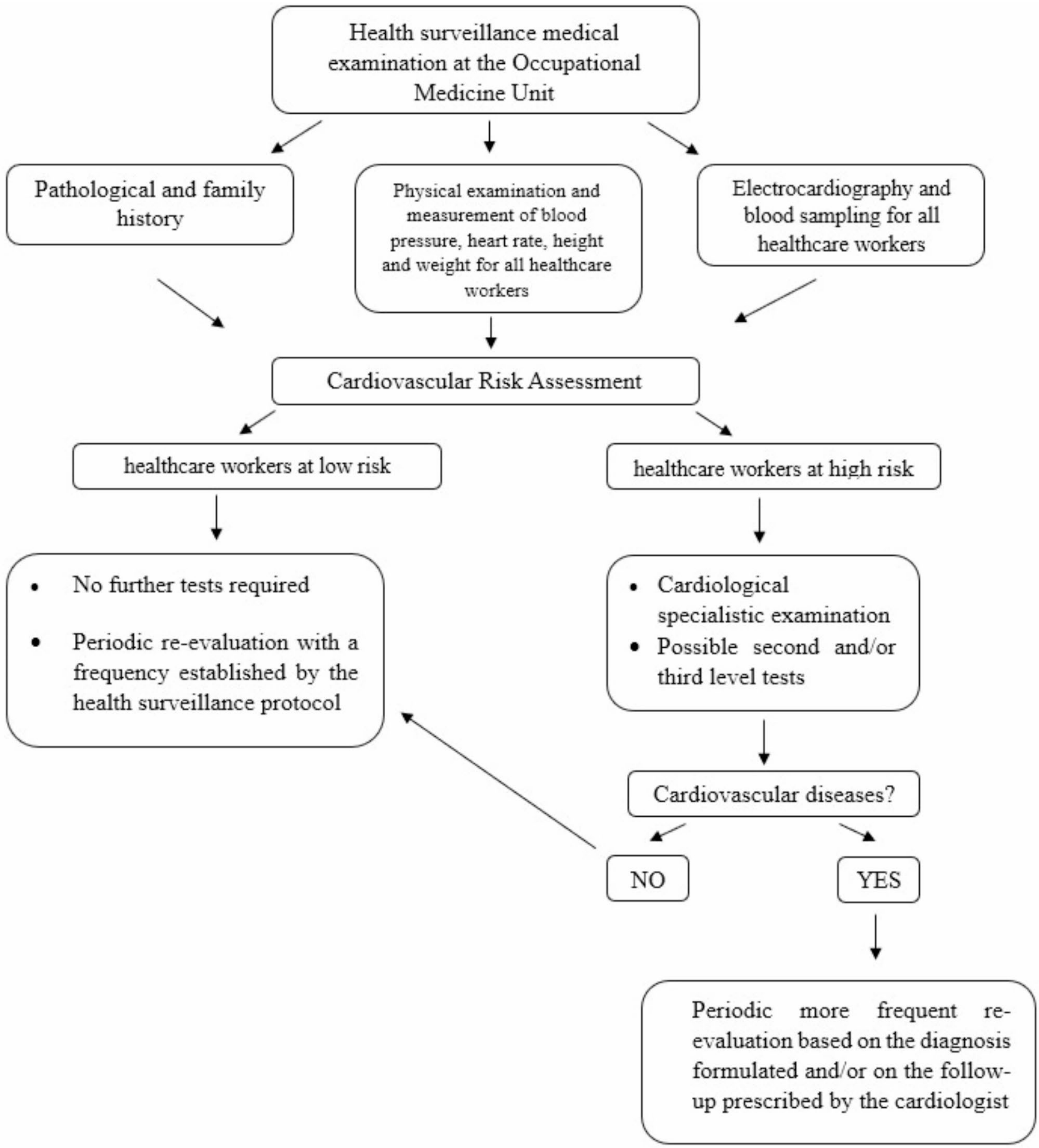

Fig. 1. Preventive health surveillance protocol for the management of cardiovascular risk among healthcare workers.

shift workers, with a higher prevalence in physicians than in other categories (*P* = 74.6%; *N* = 64.8%; O = 57.1%; NH = 17.4%). Non-healthcare workers showed a higher prevalence of alterations in SBP and DBP measurements and of impaired fasting blood glucose compared to doctors. A greater prevalence of altered ESR values was observed among other healthcare workers compared to physicians (O = 45.9%; *P* = 28.3%;).

Of the total HR-HCWs, *n* = 1116 (60.9%) had a negative history of CVDs and *n* = 717 (39.1%) had a known history of CVDs. Among these, the most frequent pathological conditions were hypertensive disorders (71.4%), followed by rhythm disorders (23.2%), anatomical-functional disorders (18.8%), other CVDs (6.4%) and finally ischemic disorders (5.7%). The distribution of previous CVDs by job title is shown in Table 2.

Non-healthcare workers showed a significantly higher prevalence of previous CVDs compared to physicians and other categories (NH = 83.1%; *P* = 62.9%; *N* = 76.1%; O = 72.1%). Hypertensive disorders had a higher

	P (*n* = 523)	N (*n* = 514)	O (*n* = 387)	NH (*n* = 409)	Total (*n* = 1833)	*p*-value
Male; *n (%)*	233 (44.6%)	143 (27.8%)	122 (31.5%)	203 (49.6%)	701 (38.2%)	< 0.0001
Age (years); average±SD (range)	41.4±13.1 (26–70)	47.2±12.0 (23–67)	47.6±14.6 (20–70)	56.4±9.4 (21–70)	47.7±13.5 (20–70)	< 0.001
BMI; average±SD (range)	23.7±3.8 (15.8–44.2)	26.0±5.2 (16.9–48.4)	25.5±4.8 (16.6–44.8)	27.0±5.2 (14.7–49.0)	25.5±4.9 (14.7–49.0)	< 0.001
Kidney diseases; *n (%)*	16 (3.1%)	21 (4.1%)	11 (2.8%)	17 (4.2%)	65 (3.6%)	0.614
Musculoskeletal diseases; *n (%)*	68 (13.0%)	215 (41.8%)	141 (36.4%)	182 (44.5%)	606 (33.1%)	< 0.0001
Psychiatric diseases; *n (%)*	20 (3.8%)	61 (11.9%)	35 (9.0%)	59 (14.4%)	175 (9.6%)	< 0.0001
Thyroid diseases; *n (%)*	87 (16.6%)	149 (29.0%)	93 (24.0%)	90 (22.0%)	419 (22.9%)	< 0.0001
Other endocrinopathies; *n (%)*	4 (0.8%)	8 (1.6%)	1 (0.3%)	3 (0.7%)	16 (0.9%)	0.201
Solid or hematologic malignancies; *n (%)*	35 (6.7%)	48 (9.3%)	26 (6.7%)	39 (9.5%)	148 (8.1%)	0.205
Diabetes mellitus; *n (%)*	10 (1.9%)	30 (5.8%)	21 (5.4%)	39 (9.5%)	100 (5.5%)	< 0.0001
Dyslipidemia; *n (%)*	179 (34.3%)	240 (46.7%)	187 (48.3%)	254 (62.1%)	860 (46.9%)	< 0.0001
Night shift workers; *n (%)*	390 (74.6%)	333 (64.8%)	221 (57.1%)	71 (17.4%)	1105 (55.4%)	< 0.0001
Physical activity; *n (%)*	201 (38.4%)	119 (23.2%)	99 (25.6%)	76 (18.6%)	495 (27.0%)	< 0.0001
Alcohol; *n (%)*	286 (54.7%)	168 (32.7%)	139 (35.9%)	152 (37.2%)	745 (40.6%)	< 0.0001
Current smokers; *n (%)*	109 (20.8%)	137 (26.7%)	105 (27.1%)	135 (33.0%)	486 (26.5%)	0.001
Familiarity; *n (%)*	351 (67.1%)	325 (64.2%)	233 (60.5%)	257 (62.8%)	1166 (64.0%)	0.215
Altered C-RP; *n (%)*	9 (6.7%)	8 (4.5%)	5 (3.8%)	3 (2.9%)	25 (4.6%)	0.535
Altered ESR; *n (%)*	147 (28.3%)	221 (43.1%)	177 (45.9%)	178 (43.7%)	723 (39.6%)	< 0.0001
Impaired fasting blood glucose; *n (%)*	26 (5.0%)	46 (9.0%)	40 (10.3%)	56 (13.7%)	168 (9.2%)	< 0.0001
Altered SBP; *n (%)*	13 (2.5%)	26 (5.1%)	16 (4.1%)	45 (11.0%)	100 (5.5%)	< 0.0001
Altered DBP; *n (%)*	5 (1.0%)	17 (3.3%)	13 (3.4%)	24 (5.9%)	59 (3.2%)	< 0.0001
Protective HDL-C; *n (%)*	480 (91.8%)	441 (85.8%)	333 (86.1%)	324 (79.2%)	1.578 (86.1%)	< 0.0001

Table 1. Baseline characteristics of the study cohort, by job title. *P* physicians, *N* nurses, *O* other HCWs, *NH* non-healthcare workers, *SD* standard deviation, *C-RP* C-Reactive Protein, *ESR* Erythrocyte Sedimentation Rate, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *HDL-C* high-density lipoprotein cholesterol.

P (*n* = 523)	N (*n* = 514)	O (*n* = 387)	NH (*n* = 409)	Total (*n* = 1833)	*p*-value
146/523 (27.9%)	223/514 (43.4%)	127/387 (32.8%)	221/409 (54%)	717/1833 (39.1%)	< 0.0001
46/146 (31.5%)	59/223 (26.5%)	28/127 (22.1%)	33/221 (14.9%)	166/717 (23.2%)	0.001
37/146 (25.3%)	40/223 (17.9%)	24/127 (18.9%)	34/221 (15.4%)	135/717 (18.8%)	0.125
2/146 (1.4%)	12/223 (5.4%)	5/127 (3.9%)	22/221 (10.0%)	41/717 (5.7%)	0.004
80/146 (54.8%)	156/223 (70.0%)	94/127 (74.0%)	182/221 (82.4%)	512/717 (71.4%)	< 0.0001
12/146 (8.2%)	15/223 (6.7%)	6/127 (4.7%)	13/221 (5.9%)	46/717 (6.4%)	0.682

Table 2. Distribution of previous CVDS by job title. *P* physicians, *N* nurses, *O* other HCWs, *NH* non-healthcare workers.

prevalence in non-healthcare workers than in physicians (NH = 82.4%; *P* = 54.8%), while rhythm disorders had a higher prevalence in physicians than in non-healthcare workers and other categories (*P* = 31.5%; NH = 14.9%; *N* = 26.5%; O = 22.1%). Ischemic disorders had a higher prevalence in non-healthcare workers compared to other categories (NH = 10%; *N* = 5.4%; O = 3.9%; *P* = 1.4%). No statistically significant differences were observed in the prevalence of anatomical-functional disorders (*p* = 0.125) and other CVDs (*p* = 0.682) in the different groups of workers.

In the whole study period, *n* = 1833 h-HCWs underwent cardiological examinations according to the health surveillance protocol: *n* = 866 (47.3%) were negative for CVDs, *n* = 967 (52.8%) were found to be diagnostic for new onset and/or already known CVDs. Among the latter, the higher prevalence of CVDs was observed in non-healthcare workers compared to physicians and other categories (NH = 65%; *P* = 44.4%; O = 45.5%; *N* = 57%). Overall, *n* = 442 (24.1%) new diagnoses of CVDs were made (Fig. 2). The distribution of new CVDs diagnoses by job title is shown in Table 3.

The higher prevalence of new CVDs diagnoses was observed in physicians compared to non-healthcare workers and other groups (*P* = 57.8%; NH = 36.1%; O = 48.3%; *N* = 43.3%). The most frequent newly diagnosed CVDs are represented by anatomical-functional disorders (*P* = 82.1%; O = 81.2%; *N* = 77.2%; NH = 65.6%).

The most frequent reasons that led to requesting a specialist cardiological evaluation were represented by ECG alterations (47.7%), followed by pathological history of CVDs (21%), new onset of cardiological COVID-19 related symptoms (20.8%), alterations in the cardiovascular physical examination performed during the health surveillance visit (12.1%). In 1.5% of cases there was more than one reason behind the request for a cardiology specialist examination.

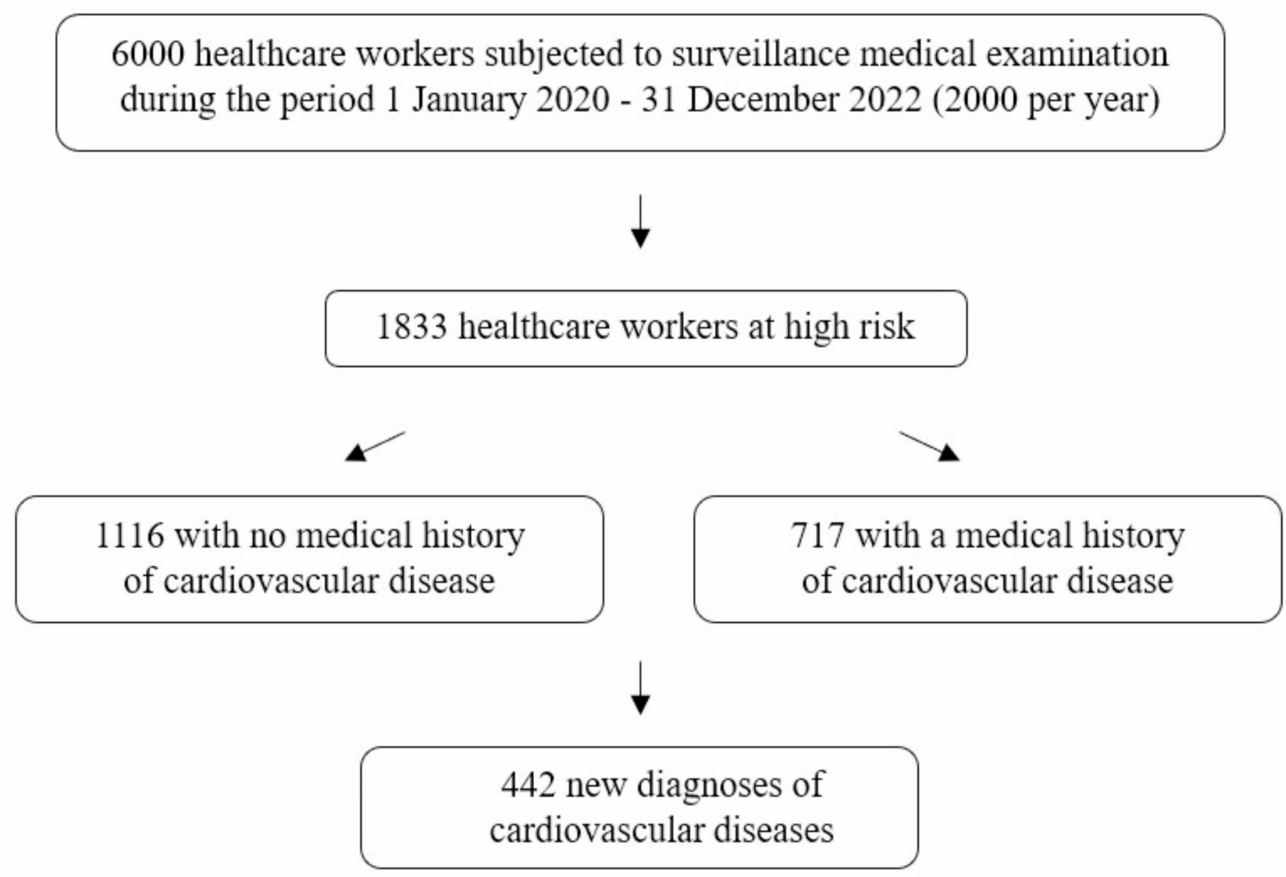

Fig. 2. Outcomes.

	P (*n* = 523)	N (*n* = 514)	O (*n* = 387)	NH (*n* = 409)	Total (*n* = 1833)	*p*-value
Total new CVDs diagnoses; *n (%)*	134/523 (25.6%)	127/514 (24.7%)	85/387 (22%)	96/409 (23.5%)	442/1833 (24.1%)	< 0.0001
Rhythm disorders; *n (%)*	28/134 (20.9%)	33/127 (26.0%)	22/85 (25.9%)	25/96 (26.0%)	108/442 (24.4%)	0.717
Anatomical-functional disorders; *n (%)*	110/134 (82.1%)	98/127 (77.2%)	6/859 (0.7%)	63/96 (65.6%)	340/442 (76.9%)	0.020
Ischemic disorders; *n (%)*	0/134 (0.0%)	0/127 (0.0%)	1/85 (1.2%)	1/96 (1.0%)	2/442 (0.5%)	0.249
Hypertensive disorders; *n (%)*	5/134 (3.7%)	4/127 (3.2%)	4/85 (4.7%)	9/96 (9.4%)	22/442 (5.0%)	0.191
Other CVDs; *n (%)*	6/134 (4.5%)	2/127 (1.6%)	2/85 (2.4%)	7/96 (7.3%)	17/442 (3.9%)	0.151

Table 3. Distribution of new CVDs diagnoses by job title. *P* physicians, *N* nurses, *O* other HCWs, *NH* non-healthcare workers.

Physicians showed a higher prevalence of isolated ECG alterations compared to the other groups (*P* = 56.4%; O = 49.6%; NH = 40.3%; *N* = 37.7%), as well as ECG alterations associated with alterations in the cardiovascular physical examination (*P* = 0.6%; O = 0.5%; NH = 40.3%; *N* = 37.7%) or with COVID-19 related symptoms (*P* = 1.5%; O = 1%; NH = 1%; *N* = 0.8%). Compared to physicians, non-healthcare workers showed a higher prevalence of physical examination alterations (NH = 12.7%; *P* = 10.3%) and of pathological history of CVDs (NH = 27.4%; *P* = 14 0.7%). Nurses showed a higher prevalence of COVID-19 related symptoms compared to other groups (*N* = 28.2%; NH = 18.3%; *P* = 16.4%; O = 14.2%).

Risk factors for CVDs

The analysis of CVDs determinants in a multivariable logistic regression model is reported in Table 4.

Male gender (aOR = 1.39; 95% CI 1.09–1.77; $p = 0.008$), age (aOR = 1.08; 95% CI 1.06–1.09; $p = 0.000$) and familiarity (aOR = 1.42; 95% CI 1.13–1.78; $p = 0.002$) were risk factors for CVDs diagnosis. Conversely, belonging to the group of non-healthcare workers (aOR = 0.54; 95% CI 0.38–0.78; $p = 0.001$) and other HCWs (aOR = 0.55; 95% CI 0.40–0.77; $p < 0.0001$) compared to physicians are considered protective factors, as well as physical activity (aOR = 0.70; 95% CI 0.54–0.90; $p = 0.005$) and night shift work (aOR = 0.64; 95% CI 0.50–0.82; $p < 0.0001$).

Determinants	aOR	95% CI	*p*-value
Gender (male Vs female)	1.39	1.09–1.77	0.008
Age (years)	1.08	1.06–1.09	0.000
Job title			
Nurses vs. physicians	1.03	0.76–1.39	0.845
Other HCWs vs. physicians	0.55	0.40–0.77	< 0.0001
Non-HCWs vs. physicians	0.54	0.38–0.78	0.001
BMI	1.01	0.99–1.03	0.264
Smoking habit (YES/NO)	1.00	0.78–1.28	0.986
Alcohol (YES/NO)	1.10	0.87–1.39	0.433
Physical activity (YES/NO)	0.70	0.54–0.90	0.005
Familiarity (YES/NO)	1.42	1.13–1.78	0.002
Diabetes mellitus (YES/NO)	1.59	0.86–2.57	0.153
Thyroid diseases (YES/NO)	0.98	0.75–1.27	0.862
Kidney diseases (YES/NO)	1.07	0.58–1.97	0.834
Dyslipidemia (YES/NO)	1.16	0.92–1.45	0.221
Night shift work (YES/NO)	0.64	0.50–0.82	< 0.0001

Table 4. Analysis of CVDs determinants in a multivariable logistic regression model. Pearson $chi^2 = 1.809,8$; Goodness-of-fit p-value = 0.451.

Determinants	aOR	95% CI	*p*-value
Gender (male vs. female)	1.09	0.85–1.39	0.502
Age (years)	1.04	1.03–1.05	< 0.0001
Job title			
Nurses vs. physicians	0.77	0.58–1.05	0.094
Other HCWs vs. physicians	0.61	0.44–0.86	0.005
Non-HCWs vs. physicians	0.45	0.32–0.65	< 0.0001
BMI	0.94	0.85–1.04	0.215
Smoking habit (yes/no)	0.91	0.70–1.19	0.496
Alcohol (yes/no)	1.02	0.80–1.30	0.883
Physical activity (yes/no)	0.97	0.73–1.27	0.804
Familiarity (yes/no)	1.22	0.96–1.55	0.096
Diabetes mellitus (yes/no)	1.13	0.72–1.78	0.600
Thyroid diseases (yes/no)	0.99	0.76–1.29	0.938
Kidney diseases (yes/no)	0.91	0.51–1.61	0.746
Dyslipidemia (yes/no)	1.05	0.83–1.34	0.673
Night shift work (yes/no)	0.85	0.66–1.10	0.213

Table 5. Analysis of new CVDs diagnoses determinants in a multivariable logistic regression model. Pearson $Chi^2 = 1.1714,8$; Goodness-of-fit P-value = 0.365.

The analysis of the determinants of new CVDs diagnoses is described in Table 5.

The only risk factor for new CVDs diagnoses was age (aOR = 1.04; 95% CI 1.03–1.05; $p < 0.0001$). Conversely, the only protective factors are represented by belonging to the group of non-healthcare workers (aOR = 0.45; 95% CI 0.32–0.65; $p < 0.0001$) and other HCWs (aOR = 0.61; 95%CI 0.44–0.86; $p = 0.005$) compared to physicians.

Discussion

Occupational medicine can provide a great contribution to the evolution of the CVR assessment model. Health surveillance of workers, mandatory by law in many countries, can be an opportunity for studying large working-age populations exposed to occupational and non-occupational risk factors and periodically subjected to clinical, instrumental and laboratory tests for CVDs. The data collected can contribute to the emergence of new CVRs, guide decisions on the evolution of current risk assessment models and represent informative databases on the epidemiological trend of cardiovascular diseases for public health decisions regarding new prevention models and health promotion programs in the general population.

In this perspective, the aim of our study was to determine the risk factors and prevalence of CVDs and to evaluate the effectiveness of the preventive health surveillance protocol applied to HCWs of a large University Hospital in Southern Italy, in terms of new CVDs diagnoses and early identification of the main CVRF.

The frequency of CVDs, in the high-risk group of the study cohort, estimated at the time of risk stratification, was 39.1% (12% of the total number of HCWs). Following the cardiological examinations required by the protocol, $n = 442$ new diagnoses were made; accordingly, the frequency of CVDs estimated at the end of the observation period, rose to 52.8% (16.1% of the total number of HCWs). Apparently, even with all the limitations and biases of this comparison, the prevalence estimates of CVDs in the study population appear higher compared to European (7%) and national (7.5%) general population[27]. Several studies in the scientific literature showed a higher cardiovascular risk in HCWs and healthcare facility staff, probably attributable to psycho-social and organizational risk factors (e.g. shift work, burnout, work-related stress)[28–33]. However, the high frequency of CVDs in the study cohort can be considered an effectiveness indicator of our health surveillance protocol, which allowed for the early identification of CVRF and pathological conditions that in the general population are often diagnosed later. In fact, in studies on general population, most prevalence estimates are obtained through the analysis of hospital discharge forms sent to the various central organizations (e.g. Ministries of Health) or through interviews carried out on a limited sample[34]. Conversely, the simultaneous execution of blood tests, anamnestic investigations, physical examinations and diagnostic-instrumental tests (e.g. detection of anthropometric parameters, measurement of vital parameters, simultaneous execution of ECGs, specialist medical visits, any further diagnostic-instrumental tests) represents a point of strength of our study. The high frequency of CVDs in the study cohort is, therefore, attributable to the high degree of in-depth diagnostic analysis.

In our study, non-healthcare workers had the highest prevalence of previous CVDs (83.1%) compared to physicians, who instead recorded the lowest prevalence of previous CVDs (62.9%). On the contrary, the higher frequency of new CVDs diagnoses was observed in physicians compared to non-healthcare workers (P = 57.8% ; NH = 36.1%). This data is in line with those present in the scientific literature regarding the greater cardiovascular risk in HCWs compared to non-healthcare workers[21,23,28].

Moreover, the analysis of CVDs determinants highlighted a protective role of night shift work (aOR = 0.64; $p < 0.0001$). This data appears to be in contrast with current knowledge on night shift work as a risk factor for the development of CVDs, especially in healthcare workers[33,35–37]. A possible interpretation of this result could be a healthy worker effect-like bias: workers suffering from previous CVDs and/or other comorbidities (e.g. Obstructive Sleep Apnea Syndrome, OSAS) were preventively excluded from night shift work through health surveillance carried out over the years, before the start of the present study[38]. This preventive action therefore resulted in a potential masking of the effects of night shift work on HCWs cardiovascular health, even attributing to it a protective role. The apparent protective role of night shift work may also depend on the length of service of night shift workers. In fact, several literature studies have demonstrated the existence of a dose-response correlation between night shift work and increased cardiovascular risk, hypothesizing the onset of health effects starting from at least five years of exposure[15]. The numerous hirings in our University-Hospital of medical, nursing and other healthcare personnel aged between 18 and 40, carried out in the observation period of this study due to the COVID-19 pandemic, may have led to an increase in number of workers with less than five years of service, who may not yet have experienced the health effects of exposure to night shift work. Nevertheless, gender and age may have acted as confounding factors in determining this result but their role was not evaluated in this study as well as length of service and duration of exposure to night shift work, representing a limitation of our study. Another limitation is the lack of use of the International Classification of Disease (ICD) for CVDs.

Despite this limitation, our study allowed us to estimate the prevalence of the main CVRF in HCWs. In particular, the prevalence of arterial hypertension in HR-HCWs, estimated at the time of risk stratification, was 27.9%. Thanks to the cardiological examination requested by the health surveillance protocol, $n = 22$ new diagnoses of arterial hypertension were made, with an increase in the prevalence of arterial hypertension to 29.1%. This data is slightly higher than the prevalence in ESC member countries and in Italy, in which the prevalence of arterial hypertension is 25% and 21.1% respectively.[27] In any case, in our study the prevalence was calculated on a population at high cardiovascular risk and not on the total number of workers. Furthermore, the data is affected by the high degree of diagnostic depth of the protocol.

It was also observed that more than half of HCWs with a new diagnosis of arterial hypertension reported at least one episode of SARS-CoV-2 infection (54.5%). These data are in line with recent evidence from scientific literature, which correlates these infection with an increased risk of new onset of arterial hypertension. In fact, the prevalence of SARS-CoV-2 infections in workers with new CVDs diagnoses (61.3%) and in workers with previous CVDs diagnoses (62.3%) was higher than in workers who did not receive any CVDs diagnosis (52.8%). Although no statistically significant correlation was observed between COVID-19 and new CVDs diagnoses, the prevalence estimates are in line with data from the scientific literature, according to which SARS-CoV-2 infection is correlated with an increased risk, even in the long term, of developing CVDs (e.g. arterial hypertension, rhythm disorders, heart failure, acute coronary syndromes)[30,39]. The COVID-19 pandemic has also led to an increase in cardiovascular risk in healthcare workers, due to psychosocial factors (e.g. burnout, work-related stress) and the alteration of organizational well-being in the workplace[40]. However, further studies are needed to evaluate the correlation between COVID-19 and increased long-term cardiovascular risk.

The analysis of CVRF also showed that 46.9% of HR-HCWs were affected by dyslipidemia, with higher values in non-healthcare workers compared to physicians (NH = 62.1% ; P = 34.3%), probably due to differences in average age between the two groups (NH = 56.4 ± 9.4 ; P = 41.4 ± 13.1). Overall, the prevalence of dyslipidemia in the study cohort was 46.9%, slightly lower than the European estimates (50% prevalence of hypercholesterolemia alone)[27]. Similar results were observed in the prevalence estimates of obesity among HR-HCWs, equal to 15.8%, significantly lower than the European (22.3%) and national (19.9%) estimates[27]. Diabetes mellitus was present in 5.5% of HR-HCWs, higher in non-healthcare workers than in physicians (NH = 9.5% ; P = 1.9%). Overall, the prevalence of this disease was in line with European (5.8%) and national (5%) estimates[27].

In our study, the main risk factors for CVDs development were age, male sex and family history of CVDs, in line with data provided by the main international organizations[1,3,5,27,41]. Similarly, physical activity has proved to be a protective factor for the development of these diseases. It is therefore essential to include health promotion programs aimed at promoting physical activity among workers in health surveillance of workers as part of global prevention strategies involving governmental interventions made by the global, European, state and local organizations. All these levels must operate in a concerted and cooperative manner to become effective and have real benefits for worker's health.

Finally, the early identification of the main CVRF in healthcare workers, the early diagnosis of unrecognized CVDs and/or any frail conditions of workers can be considered valid tools for protecting the health and safety of workers. In fact, our health surveillance protocol was effective in finding new CVDs diagnoses in age groups difficult to assess through cardiovascular risk charts, in accordance with the current recommendations of the ESC Guidelines (class of recommendation IIb, level of evidence C)[5,8].

This kind of approach allows both to prevent acute events (e.g. accidents at work) and to better manage chronic pathologies, also reducing costs of lost working days. Furthermore, the protection of the health of healthcare workers is also of fundamental importance for the protection of frail patients assisted, in line with what has already been observed in previous studies[24–26].

Conclusions

In conclusion, our results showed how the health surveillance protocol established by the Operative Unit of Occupational Medicine was effective in early identifying the main CVRF in HR-HCWs, in early diagnosis of unrecognized CVDs and in identifying any conditions of fragility and/or hypersensitivity susceptible to worsening, in order to guide the adoption of adequate protection measures.

All these aspects, if on the one hand can represent valid tools for preventing long-term complications and reducing costs of lost working days, on the other hand allowed us to highlight critical issues relating to the high prevalence of CVRF in HCWs, laying the foundations for future primary prevention and counseling interventions as part of the health promotion and TOTAL WORKER HEALTH programs.

Finally, our occupational health example of a protocol for evaluating the cardiovascular risk profile in a working age population can represent a model that can be applied to the public health and general population. In this perspective, more studies like ours are necessary, allowing the results to be networked in order to create solid scientific evidence in relation to the emergence of new CVRF and guide public health decisions regarding new prevention models and health promotion programs in the general population, in line with the current "One Health" approach.

Data availability

The dataset used and analysed during the current study available from the corresponding author on reasonable request.

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Author contributions

Project administration and validation: L.V. and L.D.M. Supervision and conceptualization: L.V., S.Sp., A.C. and L.D.M. Methodology, data curation and formal analysis: G.D., G.G., S.So., F.P.B., D.T., S.Z. and G.B. Software: F.P.B. Writing—original draft: L.V., S.Sp., A.C. and L.D.M. Investigation and Writing—review and editing: L.V., S.Sp., A.C. and L.D.M. All authors contributed to the interpretation of results and critical revision of the draft. All authors have seen and approved the submitted version.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

Correspondence and requests for materials should be addressed to L.V.