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Cardiovascular risk burden and guideline-recommended lipid and blood pressure goals in an Italian Cohort: findings from the HUMTELEMED web-based platform

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Abstract

Background Although the 2021 European Society of Cardiology (ESC) guidelines and Systematic COronary Risk Estimation 2 (SCORE2) models provide structured risk assessment, their complexity may hinder routine use. The web-based platform HUMTELEMED was developed to integrate cardiovascular risk (CVR) stratification and therapeutic targets in a user-friendly interface. We evaluated CVR distribution, the proportion of patients meeting LDL-cholesterol (LDL-C) and blood pressure (BP) goals, and the use of lipid- and BP-lowering therapies in a large Italian cohort.

Methods This cross-sectional study included 7260 anonymised adults aged ≥ 40 years who accessed the platform between December 2022 and September 2024. Most were in primary prevention, without established CV disease (99.5%, n = 7224). CVR was stratified using SCORE2, SCORE2-Older People (OP), and 2021 ESC charts. Proportions of patients meeting guideline-based LDL-C and BP goals were also assessed overall and in subgroups.

Results Mean age was 59.4 ± 11.8 years; 55.3% (*n* = 4046) were male, 46.5% (*n* = 3373) had hypertension, 18.3% (n = 1298) obesity, 8.5% (*n* = 617) diabetes, 11.8% (*n* = 860) chronic kidney disease, 16.0% (*n* = 1165) peripheral artery disease, and 37.2% (n = 2705) reported smoking. CVR distribution was 21.9% (*n* = 1593) low-to-moderate, 38.1% (*n* = 2764) high, and 40.0% (*n* = 2903) very high/extreme. LDL-C goals were met by only 11.3% (*n* = 819) overall and 15.9% (*n* = 342) of those on LLT. BP goals were met by 75.6% (*n* = 5492) overall, and by 68.3% (*n* = 2304) of patients on antihypertensive therapy. Goal meeting declined with increasing CVR: LDL-C, 44.8% low-to-moderate vs. 13.8% high vs. 11.6% very high/extreme ($p < 0.001$); BP, 89.5% vs. 78.6% vs. 65.4% ($p < 0.001$). Subgroup analyses showed lower proportions meeting LDL-C and BP goals in men (10.6% vs. 12.0% and 73.1% vs. 78.7%, respectively; $p < 0.001$), older adults (10.6% vs. 11.4% and 70.8% vs. 76.9%, respectively; $p < 0.001$), and individuals with obesity (9.0% vs. 13.8% and 63.0% vs. 83.1%, respectively; $p < 0.001$).

Conclusions In this large real-world Italian cohort, the proportion of patients meeting LDL-C and BP goals was critically low, particularly among those at the highest CVR, despite pharmacological treatment. These findings highlight

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the urgent need for improved implementation of guideline-based prevention strategies, including greater use of combination therapies, better risk communication, and stronger adherence to ESC recommendations.

Keywords Cardiovascular risk, SCORE2/SCORE2-OP, LDL-cholesterol, Blood pressure, Lipid-lowering therapy.

Background

Cardiovascular diseases (CVD) continue to represent a significant global health burden, contributing substantially to morbidity and mortality rates worldwide [1]. Over the past several decades, numerous cardiovascular risk (CVR) prediction models have been developed to estimate an individual's likelihood of experiencing major cardiovascular events, such as myocardial infarction or stroke.

In Europe, the Systematic COronary Risk Estimation 2 (SCORE2) and SCORE2-Older People (SCORE2-OP) models, introduced in 2021 by the European Society of Cardiology (ESC) as modifications of the previous SCORE model, incorporate sex- and region-specific algorithms to predict the 10-year risk of fatal and non-fatal cardiovascular events [2, 3]. In conjunction with the 2021 ESC Guidelines on CVD prevention, these models provide healthcare professionals with comprehensive tools for patient risk stratification and guide effective preventive interventions. Despite their demonstrated efficacy, these tools' complexity and time-intensive nature may limit their integration into routine clinical practice.

Numerous online calculators based on the SCORE2 and SCORE2-OP models have been developed to facilitate CVR stratification among physicians. Some of these tools are specifically designed to assess patients in primary prevention, given that the SCORE2 and SCORE2-OP models have been validated solely for this purpose. According to the 2021 ESC Guidelines on CVD risk charts, the presence of cardiovascular comorbidities, such as type 2 diabetes mellitus (T2DM), chronic kidney disease (CKD), and known atherosclerotic cardiovascular disease (ASCVD), significantly increases an individual's overall CVR, and SCORE2/SCORE2-OP should not be applied [4].

To address these limitations, we developed the web-based software tool HUMTELEMED to provide a simplified, user-friendly interface for integrating the SCORE2 and SCORE2-OP models with the 2021 ESC guidelines recommendations on CVD prevention. The reliability of HUMTELEMED as a clinical decision support tool for CVR stratification, compared to SCORE2 and 2021 ESC guidelines recommendations, has already been proven in a previous study. We performed a previous cross-sectional study on 1306 consecutive patients aged over 40 years referred to our centre for the diagnosis and management of hypertension and dyslipidemia. In this study, two double-blind operators assessed the CVR and classified each patient into low-moderate-, high-, and very-high-risk categories by using the manual conventional method (SCORE2/SCORE2-OP charts and consultation of the 2021 ESC guidelines) and the web app HUMTELEMED, resulting in a 97.5% concordance between the two methods [5].

In the present study, we comprehensively analysed the distribution of CVR, the proportion of patients meeting guideline-recommended goals for both low-density lipoprotein cholesterol (LDL-C) and office blood pressure (BP), and the patterns of lipid- and BP-lowering therapy use in a large real-world Italian cohort, to investigate possible gaps between recommendations made by guidelines and real-life data.

Methods

Study design and population

This was an observational cross-sectional study, based on the extrapolation of data from the www.humtelemed.it dataset, collected between December 2022 and September 2024. The dataset used in the present study is deposited in a repository (https://doi.org/10.7910/DVN/YDIORA) and is available upon reasonable request from the authors, in accordance with the privacy policies of the HUMTELEMED platform. www.humtelemed.it is a validated, web-based platform designed for CVR assessment and guideline integration in clinical practice. It is widely used across Italian outpatient services, preventive cardiology programs, and primary care practices. The web app is open, and data can be entered by both physicians and patients themselves, once they have been trained on how to use the platform. Therefore, the population covered by the study consists of the community-dwelling population referred to general practitioners or specialists working in the CV field. The geographical distribution of user access between December 2022 and September 2024 was reported in the Additional File 1 Figure S1. The platform aggregates clinical and laboratory data from adults undergoing CVR evaluation, ensuring standardized input and quality control procedures. These features enhance data reliability and support generalizability to similar European CV prevention settings.

The web-based application does not collect personally identifiable or sensitive information to uphold confidentiality and privacy. The anonymous data of the web platform converge and are managed by the Internal Medicine

and Geriatrics, "Hypertension Excellence Centre" of the European Society of Hypertension, IRCCS INRCA, Ancona, Italy, through SF, AG and RS, owners of the web app, in compliance with the General Data Protection Regulation (GDPR) regulations. This study was conducted according to the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments, as well as relevant local regulations (CE INRCA, Ancona, Italy; Approval Code: SC/14/443; Approval Date: 24 July 2014) governing the utilisation of secondary data for research purposes.

Data collection and definitions

In the web application, completion of all required parameters (i.e., the variables analyzed in the study) is mandatory to obtain the patient's CVR estimate. The dataset also initially included "sham cases" used for testing the app and multiple entries from patients who repeated the assessment. For data analysis, the dataset was carefully cleaned to ensure reliable results and minimize bias. Consequently, no missing variables were present among the enrolled patients. The geographical origin of data and the study population selection process is summarized in Additional File 1: Figure S1.

Following the cleaning work, 7260 complete records from individuals aged ≥ 40 years were deemed valid for analysis. The age threshold of 40 years is consistent with the ESC guidelines recommendations for CVR assessment. Our web-app is based on SCORE2/SCORE2-OP and ESC risk charts, which refer only to individuals aged 40 or older [4]. Only Italian subjects were included in the analyses (Italy is an epidemiologically defined moderate-risk region according to ESC guidelines). Primary CV prevention was defined by the absence of any previous CV event. The 0.5% ($n = 36$) of patients were in secondary CV prevention due to history of previous ASCVD, such as myocardial infarction, ischemic stroke, or symptomatic peripheral artery disease (PAD). Considering this relatively small proportion of patients in secondary CV prevention in our cohort and also that according to the ESC risk charts, they fall automatically in the very-high or extreme CVR class, we therefore decided to simply include them in the overall analyses and not perform further sensitivity analysis after their exclusion [4]. Key demographic, anthropometric, and clinical parameters were extracted from the dataset for subsequent analysis. The variables taken into account were the following: age, sex, body mass index (BMI), office systolic blood pressure (SBP) and diastolic blood pressure (DBP), and a comprehensive lipid profile. The lipid profile encompassed total cholesterol, high-density lipoprotein cholesterol (HDL-C), triglycerides, and low-density lipoprotein cholesterol (LDL-C), the latter calculated using the Friedewald equation as modified by Martin [6]. The estimated glomerular filtration rate (eGFR) was computed using the Cockcroft-Gault equation.

Patients were defined as affected by obesity if BMI ≥ 30 kg/m^2. Further clinical variables included smoking status, personal history of T2DM along with the duration since its diagnosis (in years), presence of PAD, intending any atherosclerotic plaque detection at carotid or limb arterial vessels, and CKD, defined as an eGFR < 60 ml/min/1.73m^2. Familial hypercholesterolemia (FH) was determined on a previous diagnosis, usually based on the combination of the positive Dutch Score screening and subsequent molecular confirmation, where available, as per clinical practice. Hypertension was defined based on repeated office BP measurements or the use of antihypertensive medications. Data on antihypertensive and lipid-lowering therapies (LLTs) were also collected to assess pharmacological management strategies within the study population.

Cardiovascular risk stratification, LDL-C and office blood pressure goals

CVR stratification was performed using the validated web application www.humtelemed.it [5] employing both the SCORE2/SCORE2-OP models and the 2021 ESC risk charts [4]. According to the 2021 ESC guidelines, four distinct CVR categories were established: low-moderate, high, very high, and extreme. For the sake of simplicity and because of the scarce prevalence in our final cohort, patients in the "extreme" category were included in the very-high risk group by category and goal affinity for the analyses. The LDL-C goals were defined based on individual risk categories: LDL-C < 100 mg/dL for low-moderate risk, LDL-C < 70 mg/dL for high risk, and LDL-C < 55 mg/dL for very high risk. Regarding BP assessment, the majority of office measurements were conducted using the Microlife® model BP3MQ1-2D and BP A200 AFib (Widnau, Switzerland), following standardised methodologies for office BP measurement [7]. The adequacy of BP control was determined according to established clinical cut-offs for office BP assessments (systolic BP ≤ 140 mmHg or diastolic BP ≤ 90 mmHg), ensuring compliance with guidelines [8].

Statistical analysis

Descriptive statistical methods were applied to summarise the demographic and clinical characteristics of the study population. Continuous variables were reported as means with standard deviations (SDs) or medians with interquartile ranges (IQRs), depending on the underlying distribution. Categorical variables were presented as absolute frequencies and percentages. Student's T-test and Analysis of Variance (ANOVA) evaluated the

difference between means of continuous normally distributed variables. Mann–Whitney and Kruskal–Wallis tests assessed the difference between medians of skewed variables. The chi-square test was used to compare categorical variables. Subgroup analyses by sex, age, and BMI have been further performed. All statistical analyses were conducted using the MedCalc® software, version 23.2.8, for Microsoft Windows.

Results

General characteristics of the study population

The demographic and clinical characteristics of the study population are presented in Table 1. The cohort was predominantly composed of middle-aged individuals (males 55.5%, n = 4026), with a mean age of 59.4 ± 11.8 years.

With respect to cardiovascular comorbidities, the prevalence of obesity was 18.3% (*n* = 1298), while T2DM and PAD were present in 8.5% (*n* = 617) and 16.0% (*n* = 1165) of participants, respectively. CKD was reported in 11.8% (*n* = 860) of the cohort. Moreover, 37.2% (*n* = 2705) of participants were either current or former smokers.

The use of antihypertensive and LLT was reported in 46.5% (*n* = 3373) and 29.6% (*n* = 2147) of patients, respectively. Office BP measurements indicated a mean systolic/diastolic blood pressure (SBP/DBP) of 127.8 ± 14.1 mmHg and 78.2 ± 9.5 mmHg, respectively. The lipid profile analysis revealed a mean total cholesterol of 199.1 ± 42.7 mg/dL and a mean HDL-C level of 57.1 ± 15.5 mg/dL. The mean non-HDL cholesterol was 142.1 ± 41.6 mg/dL, and the median triglycerides level was 100 mg/dL (IQR 75–138 mg/dL). The mean LDL-C concentration was 118.6 ± 51.7 mg/dL.

Cardiovascular risk stratification, LDL-C and office blood pressure goals

Participants in primary cardiovascular prevention were 99.5% (*n* = 7224), while only 0.5% (*n* = 36) had were considered in secondary prevention, as per history of previous ASCVD. The median SCORE2/SCORE2-OP was 6% (IQR: 3–10%). Based on the CVR assessment conducted via the web application HUMTELEMED, participants were categorised into three CVR groups: low-moderate risk (21.9%; *n* = 1593), high risk (38.1%; *n* = 2764), very high risk/extreme (39.2%; *n* = 2903).

The prevalence of office BP control (SBP/DBP ≤ 140/90 mmHg) in the entire population was 75.6% (*n* = 5492). However, only 11.3% (*n* = 819) of the entire cohort had LDL-C levels under the risk-based goals (Fig. 1). Among individuals taking LLT (29.6%, *n* = 2147), only 15.9% (*n* = 342) had their LDL-C levels under the risk-based goals.

In terms of CVR, individuals in the high and very-high/extreme categories showed a higher prevalence of males in the overweight spectrum of BMI, with higher mean SBP, DBP and blood lipids. The same categories were also associated with an increased prevalence of cardiovascular comorbidities, particularly hypertension, PAD, and CKD (Table 2). Moreover, the high and very-high risk groups demonstrated the greatest proportion of individuals with LDL-C levels above the goal across the entire cohort and the lowest rates of LDL-C goal among those already taking LLT (Fig. 2). Similarly, the proportion of patients at

Table 1 Baseline characteristics of the overall study population (*n* = 7260)

Demographics and Anthropometrics	Value
Age (years)	59.4 ± 11.8
Sex (male prevalence, %, n)	55.5 (*n* = 4026)
Body Mass Index (kg/m^2)	26.2 ± 4.6
Obesity (%, n)	18.3 (*n* = 1298)
Cardiovascular Risk Factors	
Smoking habit (%, n)	37.2 (*n* = 2705)
Familial Hypercholesterolemia (%, n)	4.4 (*n* = 321)
T2DM (%, n)	8.5 (*n* = 617)
Hypertension (%, n)	46.5 (*n* = 3373)
Peripheral artery disease (%, n)	16 (*n* = 1165)
eGFR with Cockcroft-Gault equation (ml/min/min/1,73 m^2)	81.6 ± 20.9
CKD (eGFR < 60 ml/min/1,73 m^2) (%, n)	11.8 (*n* = 860)
CKD stage 4 (eGFR < 30 ml/min/1,73 m^2) (%, n)	1.7 (*n* = 126)
ASCVD (%, n)	0.5 (*n* = 36)
Blood Pressure Parameters	
Systolic BP (mmHg)	127.8 ± 14.1
Diastolic BP (mmHg)	78.2 ± 9.5
BP at goal (%, n)	75.6 (n = 5492)
Antihypertensive therapy (%, n)	46.5 (n = 3373)
BP at goal on antihypertensive therapy (%, n)	68.3 (n = 2304)
Lipid Profile Parameters	
Total cholesterol (mg/dl)	199.1 ± 42.7
HDL-C (mg/dl)	57.1 ± 15.5
Triglycerides (mg/dl)	100 (75–138)
LDL-C (mg/dl, Friedewald modified)	118.6 ± 51.7
Non-HDL-C (mg/dl)	142.1 ± 41.6
Risk-based LDL-C at goal (%, n)	11.3 (n = 819)
LLT (%, n)	29.6 (n = 2147)
Risk-based LDL-C at goal on LLT (%, n)	15.9 (n = 342)
Cardiovascular Risk Stratification	
SCORE2/SCORE2-OP (%)	6 (3–10)
Low-to-moderate CV risk (%, n)	21.9 (n = 1593)
High CV risk (%, n)	38.1 (n = 2764)
Very High and Extreme CV risk (%, n)	40.0 (n = 2903)

BMI Body Mass Index, *CV* Cardiovascular, *T2DM* Type 2 Diabetes Mellitus, *PAD* Peripheral Artery Disease, *BP* Blood Pressure, LLT Lipid Lowering Therapy, *HDL-C* High-Density Lipoprotein-Cholesterol, *LDL-C* Low-Density Lipoprotein-Cholesterol, *eGFR* estimated Glomerular Filtration Rate, *CKD* Chronic Kidney Disease, *ASCVD* Atherosclerotic Cardiovascular Disease

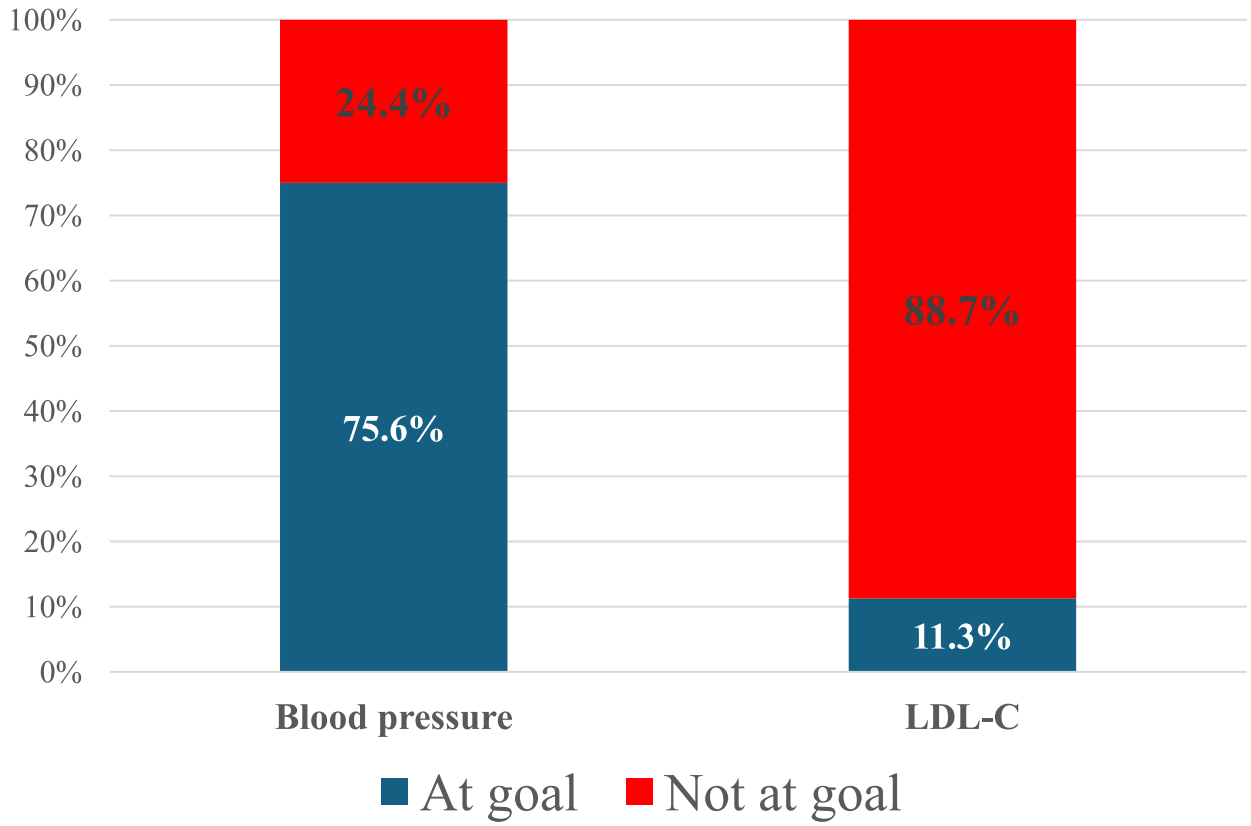

Fig. 1 Blood pressure and low-density lipoprotein cholesterol goals in the overall population. LDL-C: Low-Density Lipoprotein Cholesterol

BP goals was lower within the two higher CVR categories (Fig. 3).

Subgroup analyses

We performed subgroup analyses after stratifying our cohort by sex, age, and BMI (Additional File 1: Tables S1–S3). According to sex, women were slightly older than men (61.1 ± 12.2 vs. 58.0 ± 11.3 years, $p < 0.001$) and had a lower BMI (25.6 ± 5.0 vs. 26.7 ± 4.1 kg/m^2, $p < 0.001$). Despite a lower mean eGFR (78.9 vs. 83.6 mL/min/1.73m^2, $p < 0.001$), women had a more favourable lipid profile, with higher HDL-C (62.4 vs. 52.9 mg/dL, $p < 0.001$) and lower triglycerides (94.0 vs. 104.0 mg/dL, $p < 0.001$), although total cholesterol and LDL-C were slightly higher. Men showed significantly higher SBP and DBP (129.3/79.8 vs. 125.9/76.3 mmHg, both $p < 0.001$), greater smoking prevalence (44.3% vs. 29.6%, $p < 0.001$), and a higher SCORE2/SCORE2-OP (7% vs. 5%, $p < 0.001$), resulting in a larger proportion classified as very high/extreme CVR (44.6% vs. 34.2%, $p < 0.001$). LDL-C goal achievement among those on LLT was higher in men (18.2% vs. 13.1%, $p = 0.001$), while overall LLT use was similar. BP control was more frequent in women (78.7% vs. 73.1%, $p < 0.001$), despite their higher CKD prevalence (14.4% vs. 9.8%, $p < 0.001$). No sex-based differences were observed for PAD, hypertension, T2DM, ASCVD, or FH.

When stratified by age, older adults (≥ 70 years, $n = 1524$) had higher SBP (131.6 vs. 126.8 mmHg, $p < 0.001$) and lower DBP (75.3 vs. 78.9 mmHg, $p < 0.001$), along with reduced eGFR (67.8 vs. 85.2 mL/min/1.73m^2, $p < 0.001$). They also had lower total cholesterol (187.7 vs. 202.2 mg/dL, $p < 0.001$) and LDL-C (107.5 vs. 121.6 mg/dL, $p < 0.001$), with no differences in HDL-C or triglycerides. Despite similar BMI, older adults had markedly higher prevalence of PAD (30.6% vs. 12.2%), hypertension (68.2% vs. 40.6%), T2DM (16.9% vs. 6.3%), and CKD (28.5% vs. 7.4%, all $p < 0.001$). Very high/extreme CVR was substantially more frequent in this group (74.2% vs. 30.9%, $p < 0.001$), and LLT use was higher (46.9% vs. 24.9%, $p < 0.001$), although LDL-C goal achievement among treated patients remained low in both groups. Office BP control was also less frequent in older participants (70.8% vs. 76.9%, $p < 0.001$).

Across BMI categories, individuals with obesity (≥ 30 kg/m^2, n = 1298) showed higher SBP and DBP (132.9/80.6 vs. 124.3/76.7 mmHg, both $p < 0.001$), higher triglycerides (120 vs. 88.5 mg/dL, $p < 0.001$), and lower

Table 2 Study population characteristics according to CVR subgroups ($n=7260$)

Risk category (n)	Cardiovascular Risk			*p*-value
	Very high/Extreme ($n=2903$)	High ($n=2764$)	Low-moderate ($n=1593$)	
Age (years)	66.6 ± 11.5	56.6 ± 9.5	51.2 ± 8.4	< 0.001
Male prevalence (%, n)	61.7 ($n=1791$)	63.3 ($n=1749$)	30.1 ($n=480$)	< 0.001
BMI (kg/m^2)	27.0 ± 4.7	26.1 ± 4.2	24.8 ± 4.6	< 0.001
eGFR (mL/min/1.73 m^2)	72.9 ± 22.1	86.4 ± 17.5	88.8 ± 18.4	< 0.001
Office SBP (mmHg)	132.6 ± 14.7	127.2 ± 12.4	119.9 ± 12.0	< 0.001
Office DBP (mmHg)	78.5 ± 10.2	79.1 ± 8.8	75.9 ± 9.3	< 0.001
Total cholesterol (mg/dL)	191.6 ± 46.2	208.3 ± 40.8	197.0 ± 36.2	< 0.001
HDL-Cholesterol (mg/dL)	54.9 ± 15.3	56.8 ± 15.1	61.5 ± 15.6	< 0.001
Triglycerides (mg/dL)	105 (80.0–146.7)	100.0 (76.0–138.0)	87.0 (63.0–115.2)	< 0.001
LDL-Cholesterol (mg/dL)	111.3 ± 68.6	128.1 ± 37.3	115.3 ± 31.0	< 0.001
Smoking habit (%, n)	51.3 ($n=1491$)	34.5 ($n=953$)	16.3 ($n=261$)	< 0.001
PAD (%, n)	40.1 ($n=1165$)	-	-	-
Hypertension (%, n)	64.4 ($n=1870$)	40.0 (n = 1106)	24.9 ($n=397$)	< 0.001
T2DM (%, n)	18.2 ($n=527$)	2.4 (n = 65)	1.6 ($n=25$)	< 0.001
CKD (eGFR < 60 mL/min) (%, n)	22.9 ($n=665$)	4.8 (n = 133)	3.9 ($n=62$)	< 0.001
Familial Hypercholesterolemia (%, n)	4.4 ($n=321$)	-	-	-
ASCVD (%, n)	1.1 ($n=33$)	-	-	-
LDL-Cholesterol at goal (%, n)	6.4 ($n=185$)	5.9 ($n=162$)	29.6 ($n=472$)	< 0.001
LLT (%, n)	43.4 ($n=1261$)	23.7 ($n=654$)	14.6 ($n=232$)	< 0.001
LDL-C at goal in LLT (%, n)	11.6 ($n=147$)	13.8 ($n=90$)	44.8 ($n=104$)	< 0.001
Office BP at goal (%, n)	65.4 ($n=1895$)	78.6 ($n=2172$)	89.5 ($n=1425$)	< 0.001
Office BP at goal in antihypertensive therapy (%, n)	62.5 ($n=1171$)	74.5 ($n=819$)	79.1 ($n=314$)	< 0.001

BMI Body Mass Index, *eGFR* estimated Glomerular Filtration Rate, *SBP* Systolic Blood Pressure, *DBP* Diastolic Blood Pressure, *HDL* High-Density Lipoprotein, *LDL* Low-Density Lipoprotein, *PAD* Peripheral Artery Disease, *T2DM* Type 2 Diabetes Mellitus, *CKD* Chronic Kidney Disease, *ASCVD* Atherosclerotic Cardiovascular Disease, *FH* Familial Hypercholesterolemia, *LLT* Lower Lipid Treatment, *BP* Blood Pressure

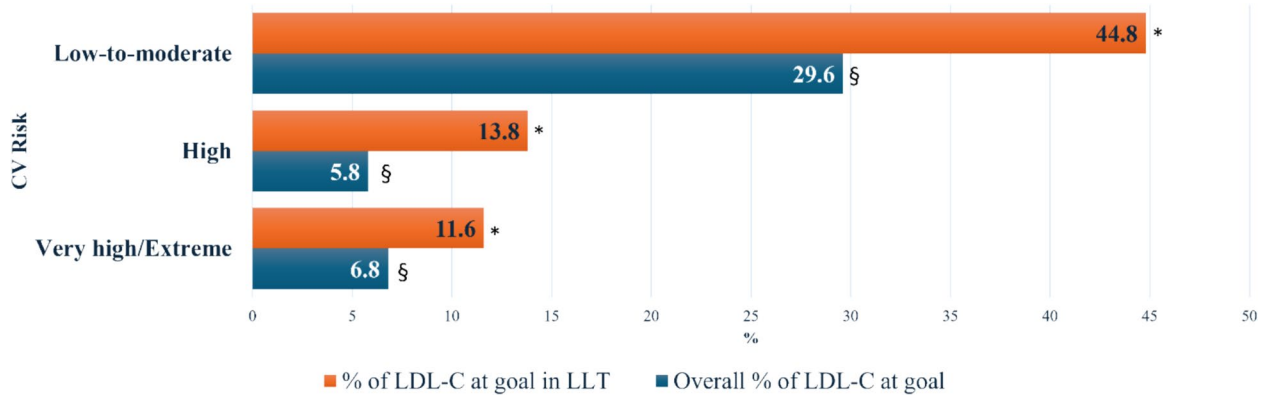

Fig. 2 Low-density lipoprotein cholesterol at goal in the overall population and in patients on lipid-lowering treatment according to cardiovascular risk. *p for trend < 0.001; §p for trend < 0.001. CV: Cardiovascular, LDL-C: Low-Density Lipoprotein-Cholesterol

HDL-C (51.5 vs. 61.6 mg/dL, $p<0.001$) compared with normal-weight participants (≤25 kg/m^2). The prevalence of hypertension (68.4% vs. 33.0%), T2DM (16.7% vs. 5.0%), CKD (15.4% vs. 9.9%), and PAD (20.3% vs. 13.9%) increased progressively across BMI groups (all $p<0.001$). Consequently, very high/extreme CVR was most frequent among obese individuals (52.0% vs. 34.0%, $p<0.001$), while attainment of LDL-C (9.0% vs. 13.8%, $p<0.001$) and

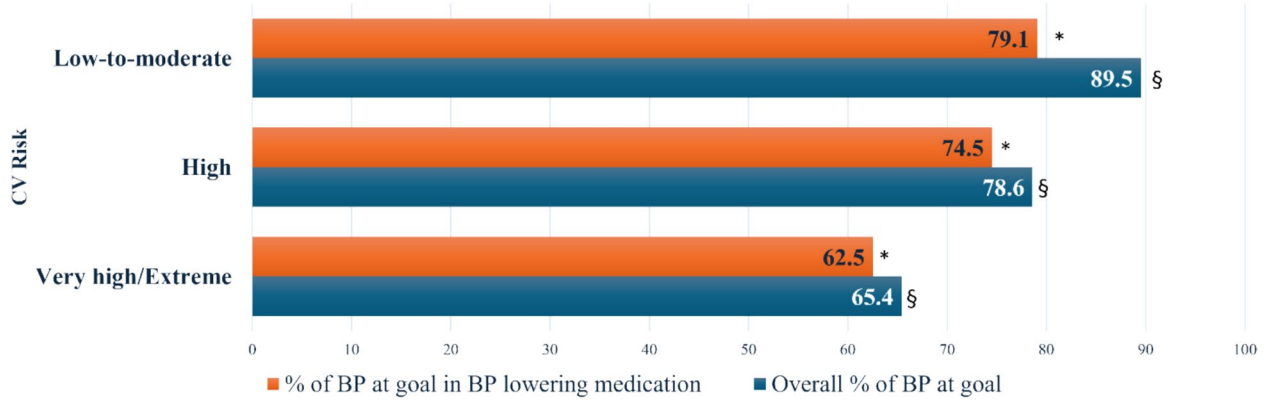

Fig. 3 Blood pressure at goal in the overall population and in patients on antihypertensive treatment according to cardiovascular risk. *p for trend < 0.001; §p for trend < 0.001. CV: Cardiovascular, BP: Blood Pressure

BP (63.0% vs. 83.1%, $p < 0.001$) goals decreased significantly with increasing BMI.

Discussion

Our study showed that the proportion of patients meeting LDL-C and BP goals is low, particularly among those at the highest CVR, in men, older adults and individuals with obesity, despite pharmacological treatment, in a wide community-dwelling population. These findings highlight that we are still far from systematically applying the recommendations suggested by the guidelines in real life and that urgent measures should be implemented in this regard.

The findings of the present study are consistent with a broader European pattern of suboptimal implementation of guideline-recommended CVR management, yet they also highlight unique and concerning deviations. Although the study population was composed primarily of younger individuals with a relatively low prevalence of overt CVR multipliers such as smoking, T2DM, CKD, and obesity, a disproportionately high percentage of participants were classified as having high or very high CVR, revealing a notable inadequacy in controlling the two crucial modifiable CVR factors: hypertension and dyslipidemia. This discordance between apparent risk factor profiles and actual CVR categorization highlights a concerning trend, as the coexistence of uncontrolled BP and lipid abnormalities contributes to an early onset and progressive trajectory of atherosclerotic vascular degeneration, culminating in an increased burden of ASCVD [9, 10]. Furthermore, existing scores may even underestimate CVR, as they often fail to account for emerging and increasingly recognized factors such as lipoprotein (a) [Lp(a)]. Elevated Lp (a) levels are now established as an independent causal factor for atherosclerotic cardiovascular disease, and incorporating Lp(a) into risk estimation models could enhance patient stratification and improve risk prediction accuracy, especially in the intermediate risk category [11]. The clinical importance of this issue is reinforced by extensive evidence demonstrating that timely and intensive lipid-lowering therapy (LLT) and antihypertensive treatment are associated with proportional reductions in cardiovascular events [12]. In our cohort, only 11.3% of individuals met their LDL-C targets based on current ESC guidelines, and even among those receiving LLT, the goal rate was only 15.9%. These rates are substantially lower than those reported in several major European observational studies, indicating a more pronounced treatment gap in our cohort. The reasons for this discrepancy are likely multifactorial, including delayed risk recognition, underprescription of high-intensity and combination therapies, and potential barriers related to digital tool adoption and healthcare access.

For example, the DA VINCI study—conducted across 18 European countries—reported that 48.2% of patients in primary prevention met LDL-C goals under the 2019 ESC/EAS guidelines, over four times higher than our findings [13, 14]. Similarly, in the Swedish National Diabetes Registry, LDL-C target attainment ranged from 36 to 47% in primary prevention settings, again significantly exceeding our observed rates [15]. The SANTORINI study, which included both primary and secondary prevention patients, found that 21.2% met their LDL-C targets at baseline, rising to 30.9% after one year of follow-up [16]. In contrast, our data indicate a persistently lower success rate despite a focus on primary prevention—a setting where earlier and more aggressive risk factor control should theoretically yield better results.

Furthermore, the use of LLT in our study appears to be both delayed and insufficiently intensive. In SANTORINI, 21.8% of patients had no documented LLT at baseline, a proportion comparable to or slightly lower than what was observed in our cohort. Both DA VINCI and SANTORINI emphasize a widespread reliance on moderate-intensity statin monotherapy, with limited adoption of combination therapies such as statins with ezetimibe or PCSK9 inhibitors, even among those at very high risk—a trend similarly evident in our study [13, 16].

In addition to lipid control, our findings revealed that about 25% of participants failed to meet office BP targets, despite mean BP values falling within the range defined as "high BP" by the 2024 ESC Hypertension Guidelines [17]. This mirrors a recurring pattern across the European data, where suboptimal hypertension control remains a key barrier to effective primary prevention. This observation further reinforces a common theme across all referenced studies: even when diagnostic thresholds are updated and treatment strategies refined, real-world application lags behind, especially in high-risk populations.

When compared to emerging models outside of Europe, such as the PREVENT risk equations introduced by the American Heart Association (AHA), important distinctions emerge in both methodology and impact. Unlike the 2013 Pooled Cohort Equations (PCEs), the PREVENT model incorporates variables such as kidney function and current statin use, while omitting race. In a recent U.S. cohort study involving 3,785 adults, PREVENT consistently estimated lower 10-year ASCVD risks compared to prior models, thereby reducing the proportion of individuals deemed eligible for statin or antihypertensive therapy. While this model may reduce overtreatment, it raises concerns about under-treatment and the potential for increased preventable events, including myocardial infarction and stroke, over time. This trade-off stands in contrast to the European trend highlighted by our findings and those of DA VINCI and SANTORINI, where failure to intensify therapy despite high estimated risk appears to be the dominant issue [18, 19].

Taken together, these comparisons underscore a paradox in contemporary CVR management: while predictive tools and clinical guidelines have evolved significantly—whether through the recalibration of risk thresholds in Europe (SCORE2) or redefinition of treatment-eligibility criteria in the U.S. (PREVENT)—real-world practice remains misaligned. In our study, the particularly low rates of LDL-C and BP goal, despite favourable baseline demographics, highlight systemic failures in early risk identification, therapeutic intensification, and implementation of evidence-based care. The contrast with both European and American cohorts illustrates that the core challenge is no longer in defining risk, but rather acting upon it in a timely and appropriate manner.

These findings collectively reinforce the urgent need for more effective implementation strategies of healthcare policy, including enhanced clinician education, adoption of high-intensity and combination therapies where indicated, integration of digital risk platforms into routine care, and continued validation of risk models through real-world outcome data. In this context, a recent randomized controlled trial demonstrated that digital health interventions can significantly improve BP control, underscoring the value of technology-driven solutions in routine care [20]. The problem of guideline adherence in clinical practice is a complex issue that involves the patient, the clinician and the clinical complexity. For this reason, multidimensional strategies involving all three of these subjects are necessary. This ranges from reducing diagnostic uncertainty and organizational barriers to integrating evidence-based decision support tools and providing education on guidelines, health awareness and clear communication on the impact of non-adherence [21].

Indeed, the present investigation was conducted using a large cohort of Italian participants, with data collected via the validated web-based platform HUMTELEMED. This multilingual and user-oriented tool holds significant potential to improve awareness of CVR factors and preventive strategies among healthcare providers and the general population, yielding clinically and socially relevant insights [5]. The digital format of the platform enables the continuous collection and aggregation of large datasets, thereby facilitating the development of extensive, population-based databases and supporting epidemiological research in CVD prevention.

For example, since its launch in 2022, the platform HUMTELEMED recorded over 17,000 individual accesses, demonstrating its potential as a framework for integrating validated predictive models with current clinical guidelines. This integration might enhance accessibility, efficiency, data acquisition, and ultimately contribute to both individualized patient care and broader public health research.

Strengths and limitations

The use of a validated, user-friendly digital tool HUMTELEMED for CVR assessment and guideline integration, a platform that allows the aggregation of large-scale data in real-time, is a significant strength of the study.

This study has several limitations. First, the cross-sectional design precludes causal inference and does not allow evaluation of longitudinal changes in CVR factors, therapeutic adherence, or outcomes. Second, although the HUMTELEMED platform provides standardized and validated data collection, it does not capture detailed information on potential drivers of suboptimal treatment, such as patient adherence, therapeutic inertia, or healthcare system barriers. Third, participation in HUMTELEMED requires access to digital infrastructure and engagement by healthcare professionals, which may introduce selection bias and limit the representativeness of the study population. Finally, while the platform is widely used across Italian outpatients and primary care settings, the findings may not be fully generalizable to populations outside Italy and Europe, in which healthcare systems have different structures and resources. Further investigations, with similar or different design, are needed to validate and generalize our results.

Conclusions

This study highlights how a substantial proportion of individuals fall short of meeting LDL-C goals based on individual CVR classification. The most concerning observation was the inverse relationship between CVR and the proportion of patients meeting guideline-recommended goals for BP and LDL-C. These findings align with other published literature, indicating that achieving guideline-recommended lipid targets remains a widespread challenge in real-life clinical practice. Multiple factors, including patient adherence, therapeutic inertia, and inadequate healthcare access, likely contribute to this gap. Addressing these barriers through patient education, appropriate pharmacotherapy utilisation (especially prompt usage of LLT in combination therapy), and enhanced healthcare accessibility is imperative for improving cardiovascular outcomes.

Abbreviations

CVD	CardioVascular Disease
CVR	CardioVascular Risk
SCORE2	Systematic COronary Risk Estimation 2
SCORE2	Systematic COronary Risk Estimation 2 Older People
ESC	European Society of Cardiology
T2DM	Type 2 Diabetes Mellitus
CKD	Chronic Kidney Disease
ASCVD	Atherosclerotic CardioVascular Disease
LDL-C	Low-Density Lipoprotein Cholesterol
BP	Blood Pressure
GDPR	General Data Protection Regulation
PAD	Peripheral Artery Disease
BMI	Body Mass Index
SBP	Systolic Blood Pressure
DBP	Diastolic Blood Pressure
HDL-C	High-Density Lipoprotein Cholesterol
eGFR	Estimated Glomerular Filtration Rate
FH	Familial Hypercholesterolemia
LLT	Lipid-Lowering Therapies
SD	Standard Deviation
IQR	InterQuartile Range
ANOVA	ANalysis Of VAriance

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12916-025-04552-7.

Additional file1: Figure S1 – Geographical distribution of user access to the web application HUMTELEMED between December 2022 and September 2024 and flowchart for the selection of the final cohort. Table S1 – General characteristics of the study population according to sex. Table S2 – General characteristics of the study population according to age. Table S3 – General characteristics of the study population according to BMI class.

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None.

Authors' contributions

ML and AG performed the analyses, wrote the manuscript, and elaborated on the tables and figures. FS and FG planned and supervised the whole study and revised the manuscript. FA and LS contributed to the data collection and preparation of the dataset. RS contributed to the study's conceptualization and supervised the whole process. All authors read and approved the final manuscript.

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Data availability

The anonymised data supporting the study's findings are all presented in the main text and Supplemental Material. Data are located in a controlled access data repository (https://doi.org/10.7910/DVN/YDIORA), and are also available from the corresponding author upon reasonable request, in accordance with the privacy policies of the HUMTELEMED platform. The timeframe for response to requests will be within a few weeks.

Declarations

Ethics approval and consent to participate

The web-based application does not collect personally identifiable or sensitive information, including names and surnames, to uphold confidentiality and privacy. Therefore, individual patient consent for publication was not required. Data storage complied with General Data Protection Regulation (GDPR) regulations. This study was conducted according to the ethical principles outlined in the Declaration of Helsinki and its subsequent amendments, as well as relevant local regulations (CE INRCA, Ancona, Italy; Approval Code: SC/14/443; Approval Date: 24 July 2014) governing the utilisation of secondary data for research purposes.

Consent for Publication

Not applicable.

Competing interests

The authors declare no competing interests.

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