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Original article

LDL-cholesterol goal achievement and guideline adherence among middle-to older-age Irish adults in a primary care setting

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ABSTRACT

Background: A significant gap exists between recommended low-density lipoprotein cholesterol (LDL-C) treatment goals and the achievement of these goals in clinical practice. In addition, there remains suboptimal utilization of lipid-lowering therapies (LLT). This study examines the prescribing pattern of LLT and the level of LDL-C goal achievement among Irish adults in a primary care setting. In addition, it identifies patient factors associated with the prescribing of LLT and LDL-C goal achievement.

Methods: This was a cross-sectional analysis of rescreen data from the Mitchelstown Cohort Study. Demographic, medication and diagnosis data were obtained from participant electronic health records. Cardiovascular risk was assessed using the SCORE tool. LDL-C goal achievement was determined using the LDL-C goals set out in the 2011 ESC/EAS guidelines for the management of dyslipidemia.

Results: Among 1183 participants (median age = 65 years), 48.5 % were prescribed LLT, 42 % of whom attained their LDL-C goal. Only 17.5 % were prescribed high-intensity statin therapy and 13 % were prescribed combination therapy. In multivariable analysis, diabetes history, polypharmacy, and hyper-polypharmacy were associated with prescribing LLT. Being male or ≤59 years of age was associated with lower likelihood of LLT prescription. Target LDL-C goal achievement was associated with male sex and age ≤64 or ≥70 years, while BMI 25–29 kg/m^2 was associated with lower LDL-C goal achievement.

Conclusion: Dyslipidemia is undertreated in this Irish primary care population with limited use of high-intensity statins. This study highlights the gap between guideline recommendations for LLT prescription and LDL-C target goals and real-world implementation of guidelines.

1. Introduction

Cardiovascular disease (CVD) is a major public health challenge and accounts for 45 % of all mortalities in Europe and 26.5 % of all mortalities in Ireland. [1–3] The total cost of CVD in the European Union (EU) is estimated to be €210 billion per year and €1.7 billion in Ireland, with healthcare services making up about half of this expenditure. [2,3]

Low-density lipoprotein cholesterol (LDL-C) is a significant risk factor for the development of atherosclerotic cardiovascular diseases. [2,4] Elevated LDL-C levels were implicated in 19.2 % of CVD deaths in the EU in 2021. [5] Robust evidence from randomized control trials has shown that reducing LDL-C levels by 1 mmol/L (40 mg/dL) using lipid-lowering therapy (LLT) reduces major adverse cardiovascular events by one-fifth both among people who previously experienced a cardiovascular event (secondary prevention) and those who were treated for primary prevention. [6,7]

LLT is therefore a first line treatment in primary and secondary prevention of CVD, [8,9] with targets set for LDL-C levels by the Task Force for the management of dyslipidemias of the European Society of Cardiology (ESC) and the European Atherosclerosis Society (EAS). [10] However, despite robust evidence for the use of LLT in primary and secondary prevention of CVD, [11,12] there is a significant gap between the

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target LDL-C goals and the achievement of LDL-C goals in practice. [13–18] For example, in a systematic review of 81 studies conducted in Europe of people at very high risk of CVD, only 18 % achieved the stringent target of LDL-C <1.8 mmol/L. [15] It has been suggested that this gap could be attributed to medication non-adherence among participants and/or guideline non-adherence among prescribers. [19]

A recent systematic review and meta-analysis of seven studies have shown that LDL-C goal attainments among Irish people is generally low, especially among people aiming for stringent LDL-C targets, including those in the very high-risk and high-risk groups. Furthermore, there was no study identifying patient characteristics which are associated with unmet LDL-C goals. In addition, there are limited data on what role prescriber adherence plays in bridging the gap to achieve the recommended LDL-C goals in Ireland. [20]

To address these gaps, the aims of this study were to examine the prescribing pattern of LLT and the level of LDL-C goal achievement in a primary care setting in Ireland. In addition, the study aims to identify the factors associated with prescribing LLT, as well as the characteristics associated with achievement of LDL-C goals.

2. Methods

2.1. Study population

The Mitchelstown Cohort Study recruited 2047 participants at baseline in 2010 from a large general practice in the Cork region of Ireland. [21] Participants were aged 51–77 years, and the sample was broadly similar to the local background population in terms of proportional age representation, marital status and education, representing a low risk of selection bias. A follow-up study was conducted in 2015, with 1378 of the baseline participants being re-screened. [22] The present study uses data from the 2015 re-screen. The follow-up involved two visits. The first visit involved urinalysis and fasting blood samples for assessment of biochemistry and hematological parameters including fasting plasma glucose, glycated hemoglobin A1c and lipoprotein profile. During the second visit, a computer assisted personal interview was used to collect various health information including medication use. In addition, physical examination was undertaken with measurements including weight, height, and resting blood pressure (BP). Detailed information on medical diagnosis and medication data was obtained during the annual screening of electronic health records which were recorded as part of the routine general practice care. Full details regarding study design, sampling methods, and data collection were described previously in the Cohort profile update. [22]

Ethics committee approval conforming to the Declaration of Helsinki was obtained from the Clinical Research Ethics Committee of University College Cork (The Cork and Kerry Diabetes and Heart Disease Study (Phase II) Mitchelstown Cohort, clinical trials.gov identifier NCT03191227). All participants gave signed informed consent, including permission to use their data for research purposes.

2.2. Demographic data

Age and sex were obtained from electronic health records. In this analysis, age was categorized into four age ranges ≤59 years, 60–64 years, 65–69 years, and 70+ years, while sex was categorized into two groups: male and female. The weight and height of each participant were measured to the nearest 0.1 kg and 0.1 cm respectively. Portable electronic Tanita WB-100MA weighing scales (Tanita Corporation, IL, USA) were placed on a firm, flat surface and were calibrated weekly to ensure accuracy. Height was measured using a portable Seca Leicester height/length stadiometer (Seca, Birmingham, United Kingdom). Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters [23] and categorized into four categories: underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25–29.9 kg/m^2) and obese (≥30 kg/m^2).

Education level and smoking status were self-reported as part of the computer assisted personal interview. Education level was included here as a measure of socioeconomic status and was categorized into one of three categories: (i) primary level only (some primary/primary equivalent), (ii) secondary level (some secondary/secondary equivalent) or (iii) third level (diploma/primary university degree/postgraduate degree). Smoking status was categorized into either current smoker, former smoker, and non-smoker. For the calculation of CVD risk using the SCORE tool, smoking status needed to be categorized as current smokers or other (to include all other categories such as former smokers, non-smokers). Thus, for the purposes of the SCORE risk calculation, former smokers and non-smokers were merged into a single category labelled "Other".

2.3. Medication data

Electronic health records were used to identify participants with prescribed LLT, with medications classified by their generic names and Anatomical Therapeutic Chemical (ATC) Codes. LLT was categorized into (i) statin monotherapy, (ii) combination therapy involving statin and non-statin LLT, or (iii) non-statin therapy. Statin monotherapy was subdivided into three sub-categories according to the intensity of the statin: high-intensity (atorvastatin 40–80 mg and rosuvastatin 20–40 mg), moderate intensity (atorvastatin 10–20 mg, rosuvastatin 5–10 mg, simvastatin 20–40 mg, pravastatin 40–80 mg, lovastatin 40 mg, fluvastatin XL 80 mg, fluvastatin 40 mg twice daily, pitavastatin 2–4 mg) or low-intensity (simvastatin 10 mg, pravastatin 10–20 mg, lovastatin 20 mg, fluvastatin 20–40 mg and pitavastatin 1 mg). [24] (Supplementary Table 1).

Polypharmacy was defined as the use of five to nine medications. Hyper-polypharmacy was defined as the use of ten or more different medications. No polypharmacy was defined as taking four or less medications (including those taking no medications). [25] Patients receiving statin monotherapy for both primary prevention (very high-/high-risk groups) and secondary prevention were categorized according to whether they were prescribed a target high-intensity statin dose as per 2011 ESC/EAS recommendations. [10]

2.4. Cardiovascular disease data

Fasting blood samples were drawn at the follow-up visit. Serum total cholesterol was measured enzymatically by an Olympus automatic analyzer (model AU5400; OlympusOptical, Tokyo, Japan). Triglyceride, high-density lipoprotein cholesterol (HDL-C), LDL-C and creatinine levels were measured on Olympus 5400 biochemistry analyzers with Olympus reagents using standardized procedures and fresh samples (Olympus Diagnostica GmbH, Hamburg, Germany). Three independent measurements of systolic BP and diastolic BP were obtained with the subject in a seated position using an Omron M7 digital sphygmomanometer (Omron Healthcare Co. Ltd., Japan). [23,26] CVD and diabetes diagnoses were obtained through electronic health records. The estimated glomerular filtration rate (eGFR) was calculated using the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equation:

$$eGFR = 141 \times \min(\kappa Creatinine,1)\alpha \times \max(\kappa Creatinine,1) -1.209 \times 0.993Age \times (1.018 \text{ if female}).$$ [27]

Participants were categorized as being treated for either primary prevention or secondary prevention of CVD. Primary prevention was defined as undergoing treatment with LLT without the presence of ischemic heart diseases, acute myocardial infarction, atherosclerosis, peripheral artery disease, cerebrovascular diseases stroke and transient ischemic attack. [28] For primary prevention, patients were further categorized by level of risk into (i) very high-risk (ii) high-risk and (iii) low-moderate risk based on 2012 European Guidelines on CVD

prevention in clinical practice. [28] The 10-year risk of fatal and non-fatal cardiovascular disease events was calculated using the SCORE algorithm for participants aged <65years. The SCORE algorithm for low-risk population was applied (26,30). The updated 10-year risk estimate for fatal and non-fatal cardiovascular diseases (SCORE2 and SCORE2-OP) was calculated for people aged 65–69 years and 70+. [29] The SCORE used to categorize individuals is outlined in Supplementary Table 1. Following calculation and categorization with SCORE and in line with the guidelines, [10,28] people with diabetes who had one or more additional CVD risk factors (smoking, total cholesterol >8 mmol/L, or systolic BP > 180 mmHg) were then re-categorized as being very high-risk, while individuals with diabetes who had no additional risk factors were re-categorized as being high-risk. Similarly, people with moderate renal function impairment (eGFR ≥30 – <60 ml/min/1.73 m^2) and severe renal function impairment (<30 ml/min/1.73 m^2) were re-categorized as high-risk and very high-risk, respectively.

Secondary prevention was defined as undergoing treatment with LLT with a documented diagnosis of CVD (ischemic heart diseases, acute myocardial infarction, atherosclerosis, peripheral artery disease, cerebrovascular diseases (stroke and transient ischemic attack). [28]

2.5. Goal achievement data

LDL-C goal achievement was determined using LDL-C goals set out in the 2011 ESC/EAS Guidelines for the management of dyslipidemias according to individual CVD risk. [10] LDL-C goals varied according to the CVD risk categorization: <3 mmol/L in patients at low-moderate risk of CVD, <2.5 mmol/L in patients at high-risk of CVD, and <1.8 mmol/L in patients at very high-risk of CVD including the secondary prevention group. [10] Details on participant categorization are shown in Supplementary Table 1.

2.6. Data analysis

The demographics of the study population were stratified by (i) prescription of LLT and (ii) achievement of LDL-C goals. Categorical features are presented as numbers (n) and percentages (%), and continuous variables are shown as a mean, plus or minus one standard deviation (SD), or a median and interquartile range (IQR) for skewed data.

The association between patients' characteristics and prescribing of LLT was examined using a multivariable logistic regression model. This model included participants' age categories, BMI, sex, smoking status, diabetes status, education level, CVD risk, and extent of polypharmacy. A second multivariable model examined associations between patient characteristics and achieving LDL-C goals. This model included participants' age categories, BMI, sex, smoking status, diabetes status, and education level. For age categories, the age group 65–69 years was used as the reference category, as it had the largest sample size among the age groups. Odds ratios (OR) and 95 % confidence intervals (CI) are shown. Statistical analysis was performed using Stata/SE 17.0 (Stata Corporation, College Station, TX, USA). For all analyses, a p-value (two-tailed) of less than 0.05 was considered to indicate statistical significance.

A sensitivity analysis was conducted to check whether the results were consistent when applying stricter LDL-C goals as recommended by the 2019 ESC/EAS guidelines for the management of dyslipidemias. The proportion of very high-risk and high-risk people who achieved their LDL-C goals was calculated, with an LDL-cholesterol goal of <1.4 mmol/L for those deemed very high-risk and a goal of <1.8 mmol/L for those deemed high-risk. The LDL-cholesterol goal for those deemed low-moderate risk remained 3.0 mmol/L. [30] The focused update guidelines released by the ESC/EAS in 2025 have the same LDL-C goals for the very high-risk and high-risk population as the 2019 guidelines and therefore this sensitivity analysis also aligns with the 2025 ESC/EAS guidelines. [31]

3. Results

A total of 1183 participants with complete data on age, sex, smoking status, systolic BP, total cholesterol, triglycerides, HDL-C, LDL-C and eGFR were included in this analysis. Their median age was 65 (60.5–69.3) years and 51.6 % were female (Table 1). Among the participants included, 1085 (91.7 %) were categorized as primary prevention, 27 (2.2 %) were categorized as secondary prevention, and 71 (6 %) had diabetes.

LLT was prescribed to 48.5 % of the participants. Participants prescribed LLT were older (67, 62.6–70.8 vs. 63, 59.4–67.6 years), had a higher percentage of females (51.7 % vs. 48.3 %), and a greater proportion of high-risk (36.9 % vs. 22 %) and very high-risk participants (16.7 % vs. 10.5 %) and when compared with those who were not prescribed LLT (Table 1).

Table 1
Characteristics of the study population according to lipid-lowering therapy prescribing (N = 1183).

	On lipid-lowering therapy N = 574 (48.5 %)	Not on lipid-lowering therapy N = 609 (51.4 %)	All participants N = 1183
Age, years (median, IQR)	67.1 (62.6–70.8)	63.2 (59.4–67.6)	65 (60.5–69.3)
Total cholesterol, mmol/L (mean, SD)	4.9 (1.1)	5.5 (0.8)	5.2 (1.0)
LDL-C, mmol/L (mean, SD)	2.8 (0.9)	3.5 (0.7)	3.20 (0.9)
Triglycerides, mmol/L (median, IQR)	1.2 (0.9–1.5)	1.1 (0.7–1.4)	1.1 (0.8–1.5)
HDL-C, mmol/L (median, IQR)	1.3 (1.1–1.6)	1.4 (1.2–1.6)	1.4 (1.2–1.6)
Systolic BP, mm Hg (mean, SD)	128.9 (18.5)	128.7 (18.3)	129 (18.4)
Diastolic BP, mm Hg (mean, SD)	75.2 (9.9)	77.2 (10)	76.1 (10.1)
BMI, kg/m^2 (mean, SD)	28.8 (4.8)	28 (7.2)	28 (6.2)
Male (n, %)	277 (48.2)	333 (54.6)	610 (51.6)
Non-smoker[a] (n, %)	296 (51.6)	329 (54.0)	625 (0.5)
Former smoker (n, %)	236 (41.1)	226 (37.1)	462 (39.1)
Current smoker (n, %)	42 (7.3)	54 (8.8)	96 (8.1)
Morbidities			
Diabetes	60 (10.4)	11 (1.8)	71 (6.0)
Moderate or severe renal impairment[b] (n, %)	56 (9.7)	23 (3.7)	79 (6.6)
Education Level			
Primary level (n, %)	167 (29.0)	126 (20.6)	293 (24.8)
Second level (n, %)	279 (48.6)	318 (52.2)	597 (50.5)
Third level (n, %)	128 (22.3)	165 (27.1)	293 (24.8)
Cardiovascular disease risk			
Primary Prevention			
Low-moderate risk (n, %)	239 (41.6)	406 (66.6)	645 (54.5)
High-risk (n, %)	212 (36.9)	135 (22.2)	347 (29.3)
Very high-risk (n, %)	96 (16.7)	64 (10.5)	160 (13.5)
Secondary prevention	27 (4.7)	4 (0.6)	31 (2.6)
Polypharmacy			
No polypharmacy (≤4 medicines) (n, %)	267 (46.5)	521 (85.5)	616 (60.9)
Polypharmacy (5–9 medicines) (n, %)	247 (43.0)	79 (12.9)	326 (32.2)
Hyper-polypharmacy (≥10 medicines) (n, %)	60 (10.4)	9 (1.5)	69 (6.8)

Abbreviations: BMI, body mass index; BP, blood pressure; HDL-C, high density lipoprotein cholesterol, LDL-C, low-density lipoprotein cholesterol.

[a] Non-smoker is defined as people who were labelled 'not applicable' on answering "Are you current or former smoker?"

[b] Moderate renal impairment was defined as having eGFR ≥30 – <60 ml/min/1.73 m^2 and severe renal impairment was defined as having eGFR <30 ml/min/1.73 m^2.

Among those prescribed LLT, statin monotherapy was prescribed to 83.6 %, with 9.3 % low-intensity, 73 % moderate intensity, and 17.5 % prescribed high-intensity statin monotherapy. In addition, 13.8 % were on combination therapy including 11.8 % on statin and ezetimibe and 1.9 % on statin and omega-3 fatty acids. Nine participants (0.65 %) were on ezetimibe monotherapy.

Among participants who were prescribed LLT, 42.1 % achieved the 2011 ESC/EAS guideline defined LDL-C goals recommended for their CVD risk. Those who achieved LDL-C goals were younger (66.3, 61.9–71.1 vs. 67.6, 63.1–70.5 years), more likely to be male (55.4 % vs. 43.0 %) and less likely to be a current smoker (6.6 % vs. 7.8 %) when compared to participants who did not achieve their LDL-C goals. Those who achieved LDL-C goals were more likely to have low-moderate risk (52.8 % vs 33.4 %) and more likely to be prescribed a high-intensity statin therapy (22.8 % vs. 13.6 %) or combination therapy (16.5 % vs. 11.7 %) when compared to participants who did not achieve their LDL-C goal (Table 2). Among those who were not prescribed LLT, 23 % were among the high-risk group and 12 % were among the very high-risk group who did not achieve their LDL-C goals (Supplementary Table 2). Among the very high-risk group including people with secondary prevention (n = 191), 26 (13.6 %) were prescribed their target statin dose (high intensity), and 10 (5.2 %) achieved their LDL-C goals (Table 3).

In multivariable logistic regression analysis, diabetes (OR = 2.27; 95 % CI: 1.06, 4.82), polypharmacy (OR = 4.74; 95 % CI: 3.47, 6.47) and hyper-polypharmacy (OR = 8.37; 95 % CI: 3.92, 17.79) were associated with greater likelihood of prescription of LLT (Table 4). Being male (OR = 0.69; 95 % CI: 0.52, 0.91)) and age (≤59 years) (OR = 0.53; 95 % CI: 0.32, 0.86) were both associated with a lower likelihood of LLT prescription.

With regard to achieving LDL-C goals (Table 5), multivariable analysis showed that people aged ≤59 years (OR = 2.08; 95 % CI: 1.18, 3.67), those aged 60–64 years (OR = 1.78; 95 % CI: 1.13, 2.82) and study participants aged 70+ years (OR = 1.58; 95 % CI: 1.02, 2.45) were

Table 2
Characteristics of participants who were prescribed lipid-lowering therapy according to low-density lipoprotein cholesterol goal achievements. [10] (N = 574).

	Achieved LDL-cholesterol goals N = 242 (42.1 %)	Did not achieve LDL-cholesterol goals N = 332 (57.8 %)
Age (years) (median, IQR)	66.3 (61.9–71.1)	67.6 (63.2–70.5)
Total cholesterol (mmol/L) (mean, SD)	4.1 (0.6)	5.4 (1.1)
LDL-C (mmol/L) (mean, SD)	2.1 (0.4)	3.3 (0.9)
Triglyceride (mmol/L) (median, IQR)	1.1 (0.8–1.5)	1.2 (0.9–1.6)
HDL-C (mmol/L) (median, IQR)	1.4 (1.1–1.6)	1.4 (1.2–1.6)
Systolic BP (mm Hg) (mean, SD)	127.4 (18.4)	130.1 (18.6)
Diastolic BP (mm Hg) (mean, SD)	74.8 (9.5)	75.5 (10.2)
BMI (kg/m^2) (mean, SD)	28.9 (5.2)	28.8 (4.5)
Male (n, %)	134 (55.4)	143 (43.1)
Nonsmoker[a] (n, %)	111 (45.8)	185 (55.7)
Former smoker (n, %)	115 (47.5)	121 (36.4)
Current smoker (n, %)	16 (6.6)	26 (7.8)
Education level		
Primary level (n, %)	69 (28.5)	98 (29.5)
Secondary level (n, %)	117 (48.3)	162 (48.8)
Third level (n, %)	56 (23.1)	72 (21.7)
Cardiovascular disease risk		
Primary prevention		
Low-moderate risk (n, %)	128 (52.8)	111 (33.4)
High-risk (n, %)	91 (37.6)	121 (36.4)
Very high-risk (n, %)	19 (7.8)	77 (23.2)
Secondary prevention	4 (1.7)	23 (6.9)
Treatment		
Non statin therapy (n, %)	1 (0.4)	14 (4.2)
Statin monotherapy (n, %)	201 (83.0)	279 (84.0)
Combination therapy (n, %)	40 (16.5)	39 (11.7)
Statin intensity		
Low-intensity (n, %)	10 (4.9)	35 (12.5)
Moderate intensity (n, %)	145 (72.1)	206 (73.8)
High-intensity (n, %)	46 (22.9)	38 (13.6)
Statin target dose		
Yes (n, %)	30 (32.6)	28 (15.1)
No (n, %)	62 (67.3)	158 (84.9)

Abbreviations: BMI, body mass index; BP, blood pressure; HDL-C, high density lipoprotein cholesterol, LDL-C, low-density lipoprotein cholesterol.

[a] Non-smoker is defined as people who were labelled 'not applicable' on answering "Are you current or former smoker?"

Table 3
The prescribing pattern of statin therapy among those deemed very high-risk (including people treated for secondary prevention) and high-risk groups.

	Achieved goals	Did not achieve goals
Very high-risk (N =191)		
Statin mono therapy (n, %)	19 (82.6)	84 (50.0)
[a]*Statin target dose (n, %)*	*10 (52.6)*	*16 (23.5)*
Combination therapy (n, %)	4 (17.0)	12 (7.1)
Non statin therapy (n, %)	0	4 (2.3)
No lipid-lowering therapy (n, %)	0	68 (40.5)
High-risk (N= 347)		
Statin mono therapy (n, %)	73 (70.2)	102 (41.9)
[a]*Statin target dose (n, %)*	*20 (25.6)*	*12 (11.7)*
Combination therapy (n, %)	18 (17.3)	16 (6.5)
Non statin therapy (n, %)	0	3 (1.2)
No lipid-lowering therapy (n, %)	13 (12.5)	122 (50.2)

[a] Statin target dose: The group of very high-risk and high-risk people who were receiving statin monotherapy at the target high-intensity statin dose as per 2011 ESC/EAS recommendations. (Very high-risk group, N = 26; High-risk group, N = 32).

Table 4
Odds ratios of prescription of lipid-lowering therapy from multivariable logistic regression.

Predictors for prescribing lipid-lowering therapy	Odds ratio	95 % confidence interval	p-value
Age (Years)			
65–69	Reference		
≤59	0.53	[0.32, 0.86]	0.012
60–64	0.88	[0.56, 1.38]	0.595
70+	1.19	[0.82, 1.73]	0.349
Body mass index			
Normal weight	Reference		
Underweight	0.54	[0.14, 2.07]	0.372
Overweight	1.32	[0.93, 1.86]	0.109
Obese	1.15	[0.79, 1.69]	0.451
Sex			
Female	Reference		
Male	0.69	[0.52, 0.92]	0.011
Smoking status			
Non-smoker	Reference		
Former smoker	1.07	[0.81,1.42]	0.596
Current smoker	0.77	[0.46, 1.29]	0.336
Diabetes status			
No Diabetes	Reference		
Diabetes	2.27	[1.07, 4.82]	0.033
Education level			
Third level	Reference		
Primary level	1.05	[0.71,1.53]	0.804
Secondary level	0.91	[0.66, 1.24]	0.568
Cardiovascular disease risk			
Low-moderate risk	Reference		
High-risk	1.34	[0.86, 2.06]	0.191
Very high-risk	1.32	[0.78, 2.24]	0.290
Polypharmacy			
No polypharmacy (≤4 medicines)	Reference		
Polypharmacy (5–9 medicines)	4.74	[3.47, 6.47]	<0.001
Hyper-polypharmacy (≥10 medicines)	8.36	[3.92, 17.79]	<0.001

Table 5
Odds ratios of achieving low-density lipoprotein cholesterol goals from multivariable logistic regression.

Predictors for goal achievements	Odds ratio	95 % Confidence interval	p-value
Age			
65–69	Reference		
≤59	2.08	[1.18, 3.67]	0.011
60–64	1.78	[1.13, 2.82]	0.012
70 +	1.58	[1.02, 2.45]	0.039
Body mass index			
Normal weight	Reference		
Underweight	0.33	[0.03, 3.62]	0.368
Overweight	0.58	[0.36, 0.95]	0.030
Obese	0.62	[0.37, 1.05]	0.077
Sex			
Female	Reference		
Male	1.63	[1.13, 2.35]	0.009
Smoking status			
Non-smoker	Reference		
Former smoker	1.44	[0.99, 2.08]	0.051
Current smoker	0.93	[0.46, 1.87]	0.843
Diabetes status			
No diabetes	Reference		
Diabetes	0.93	[0.52,1.67]	0.829
Education level			
Third level	Reference		
Secondary level	0.94	[0.60, 1.46]	0.786
Primary level	0.95	[0.58, 1.57]	0.866

more likely to achieve their LDL-C goals than those aged 65–69 years. In addition, males were more likely to achieve LDL-C goals than females (OR = 1.63; 95 % CI 1.13,2.35). Patients categorized as overweight were less likely to achieve LDL-C treatment goals compared to people categorized as normal weight (OR = 0.58; 95 % CI: 0.36, 0.95).

When the 2019 ESC/EAS guideline is applied, 14 (4.0 %) of the 347 people in the high-risk group and 5 (2.6 %) of the 191 people in the very high-risk group achieved the stricter 2019 LDL-C goals of <1.8 mmol/L and <1.4 mmol/L respectively (Table 6).

4. Discussion

Among this population of Irish adults attending primary care, just under one-half of participants was prescribed a LLT, primarily statin therapy. Even though 45.5 % were eligible for high-intensity statin therapy, a moderate intensity statin was the most prescribed form of LLT, and just one-fifth of those within the high-risk/very high-risk or secondary prevention group were prescribed a target high-intensity statin dose. Less than 40 % of those prescribed LLT achieved their LDL-C goals according to their risk category. While diabetes diagnosis was associated with prescription of LLT, males and those aged ≤59 years were less likely to be prescribed LLT. Furthermore, females, people aged 65–69 years of age and those who were categorized as overweight were less likely to achieve their LDL-C goals.

Dyslipidemia is a significant modifiable risk factor for CVD. [32]

Table 6
Proportion of those deemed very high-risk (including people treated for secondary prevention) and high-risk groups who achieved the LDL-C levels recommended in the 2019 ESC/EAS guidelines.

Guidelines	LDL-C goals	High risk (n, %) N = 347	Very high risk (n, %) N = 191
2011 ESC/EAS guidelines	LDL-C < 2.5 mmol/L	86 (24.7)	42 (21.9)
2019 ESC/EAS guidelines	LDL-C <1.8 mmol/L	14 (4.0)	18 (9.4)
2019 ESC/EAS guidelines	LDL-C <1.4 mmol/L	4 (1.2)	5 (2.6)

However, studies have shown that outpatients, whether treated for primary or secondary prevention, may not achieve recommended LDL-C goals. [18,20,33] According to the Irish data analysis of the DYSIS study, 34 % of Irish participants did not achieve the LDL-C goals of <3 mmol/L and <2.5 mmol/L. Similarly, the German and Belgian results from DYSIS reported that 58 % and 56 % respectively did not achieve recommended LDL-C goals of <3 mmol/L, <2.5 mmol/L and <1.8 mmol/L. [34–36] According to the German CoRiMa study, the achievement of LDL-C goals is low overall, with 24 % of 79,689 people with hyperlipidemia achieving target LDL-C levels, and only 14 % of 38,484 high-risk people with coronary artery disease and/or diabetes achieving their target LDL-C level. [37]

The Irish Health Service Executive has rolled out a Chronic Disease Management Programme in general practice since 2020. The programme is targeted at specific chronic conditions including ischemic heart disease and type 2 diabetes mellitus. Data from the first four years of the programme showed that among 15,081 participants with type 2 diabetes and ischemic heart diseases, 49 % had an LDL-C of <1.8 mmol/L and 31.7 % had an LDL-C of <1.4 mmol/L. In addition, the report showed that among 31,686 participants with ischemic heart diseases, the majority of participants had an LDL-C between 1.8 and 2.5 mmol/L and 15.2 % achieved an LDL-C ≤1.4 mmol/L. [38] These findings demonstrate that achieving LDL-C goals remains a challenge, in particular among those in the very high-risk category, even among people enrolled in a targeted clinical programme.

Despite the evidence of statin efficacy among eligible individuals for primary and secondary prevention of CVD, [10,39] the underutilization of statin therapy in both groups has been documented in international and national studies. [16,17] Of concern in the current study are the 33 % of those who were not prescribed a statin but who were classified as secondary prevention or as high-risk/very high-risk primary prevention. These results align with findings elsewhere in Europe. In the Netherlands, while 67 % of high-risk people were on LLT, 7 % were prescribed high-intensity statin therapy and 2 % statin plus ezetimibe therapy. [40] Similarly, the DA VINCI study highlighted the underutilization of LLT and non-optimal statin dose prescribing among high-risk and very high-risk people in Central-Eastern Europe. [41]

In Ireland, as of 2020, there are just six designated lipid clinics, all in secondary care settings, and one specialist lipid nurse. [42] This highlights the limited resources allocated to tackle dyslipidemia in Ireland and that the responsibility for managing dyslipidemia falls mostly on general practitioners. Agar et al. have reported that there is no defined strategy to address lipid disorders, especially in primary care settings in Ireland. [42] According to the ACS Euro Path III study, general practitioners (GPs) are limited in their care of people prescribed LLT for secondary prevention due to lack of knowledge of optimal therapies, discomfort at prescribing non-statin LLT, and hesitation in making referral to specialists for this condition. [43] This emphasizes the importance of embedding a guideline-directed approach to lipid management in primary care. Such an approach could enable GPs to assess goal attainment and individualize treatment based on each patient's risk SCORE. [17,43]

The findings from the present study align with those found in a retrospective cohort study conducted in the United Kingdom, which reported that diagnosis of diabetes and being ≥65 years of age were strong predictors for prescribing LLT. [44] However, our findings contradict those shown in a recent Dutch study, which found that females were less likely to be prescribed statin treatment than males. [45] However, Kiss et al. included only primary prevention patients in their study. [45] A 2019 survey reported that 82 % of Irish females had visited their GP in the previous 12 months compared to just 62 % of Irish males. [46] This may lead to GPs having greater opportunities to identify and treat dyslipidemia and cardiovascular risk factors in female patients. [44]

Few studies have assessed variables associated with LDL-C treatment goals. Breuker et al. reported that very high-risk females with diabetes were less likely to achieve their LDL-C goals than similar males. [47] Berteotti et al. reported female sex as the only independent variable

associated with low probability of achieving LDL-C goals for treated and untreated high-risk participants. [48] A possible explanation for this is medication non-adherence. According to a study by Nanna et al., females were more likely to decline or discontinue statin therapy and were less likely to believe in the safety and effectiveness of statins than men. [49]

It should be noted that the data for the present study was collected prior to the advent of biological lipid-lowering therapies. However, at present the use of these agents is limited in Ireland and their prescription is restricted to a small number of approved prescribers. [50] Given the cost of these biological agents [51] and their parenteral use, it is preferred that they are restricted to use in those at exceptionally high cardiovascular risk and those with ongoing failure to achieve goals, despite optimal treatment with oral agents. [51] With just 40 % of those prescribed LLT in the present study achieving their LDL-C goal, and the majority of those prescribed a statin being prescribed a moderate intensity agent, there is clear scope to expand the use of high intensity oral agents before considering the prescription of biologicals in the general practice population. Future studies should be conducted to identify facilitators and barriers that influence prescribers' implementation of guideline recommendations, and in particular, prescribing of high-intensity statins.

This study provides a valuable insight into prescribing patterns of LLT and LDL-C goal achievement in an Irish primary care setting. However, it has some limitations. It is a cross-sectional observational study. Therefore, LDL-C levels were measured at a single timepoint only and pre-treatment LDL-C levels are not available. The sample size of the study population was large compared to the Irish arm of comparable studies such as The DA VINCI study, [17] McCaughey et al., 2022 [16] and Ci'fkova et al., 2019 [52]; however, the data were collected in a single primary care center in the greater Cork region and this may limit the generalizability of the study. In addition, data were not available on some patients and prescriber factors that may influence prescription of LLT and achievement of LDL-cholesterol goals. Such factors include medication adherence, private medical insurance, and number of prescribers in the primary care center.

Choice of statin may have been influenced at the time of data collection by guidance from the Irish Health Service Executive, which at the time recommended moderate intensity simvastatin as the first-choice statin 53. At present, there is no national electronic health record in Ireland and there exist few datasets that record both clinical parameters and medications data. Therefore, although the study data were collected in 2015, this is a comprehensive and relevant dataset to study recent trends in dyslipidemia management in Irish primary care settings. Additionally, the issues and patterns highlighted by this research are likely still relevant today, making this study a useful starting point for understanding ongoing trends.

5. Conclusion

This research highlights the gap between guideline recommendations and implementation of these recommendations in real world practice. This is apparent in the inadequate achievement of LDL-C goals among people at high risk of cardiovascular events. In addition, the prescribing pattern of LLT indicates that many people remain suboptimally treated. Further studies should be conducted to identify the barriers toward the prescribing of high intensity statins and the implementation of contemporary, more aggressive LDL-C targets in Irish primary care settings. In addition, longitudinal multicenter studies are needed to provide a robust data on dyslipidemia care in Ireland.

Ethical consideration

Ethics committee approval conforming to the Declaration of Helsinki was obtained from the Clinical Research Ethics Committee of University College Cork (The Cork and Kerry Diabetes and Heart Disease Study (Phase II) Mitchelstown Cohort, clinical trials.gov identifier NCT03191227). All participants gave signed informed consent, including permission to use their data for research purposes.

Data availability statement

The data underlying this article will be shared on reasonable request to the corresponding author.

Author contribution

Rehab Elhiny: conceptualization, study design, data analysis, interpretation of results, writing the manuscript. Margaret Bermingham: conceptualization, methodology, study design, supervision, writing - review & editing. Linda M O'Keeffe: conceptualization, methodology, supervision, writing - review & editing. Maria Donovan: conceptualization, methodology, supervision, writing - review & editing. Seán R. Millar: clarified data definitions, assisted with interpretation of variables, writing - review & editing. Stephen Byrne: supervision, writing-review & editing and final approval of the version to be published.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Rehab Elhiny reports financial support was provided by Egyptian Cultural and Educational Bureau. Margaret Bermingham reports financial support was provided by Novartis Pharmaceuticals Corporation. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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