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ORIGINAL ARTICLE

A snapshot of lipid levels in the Republic of Ireland in 2017

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Abstract

Background Abnormalities in blood lipid levels are causally linked with cardiovascular disease and pancreatitis. Data is limited regarding lipid abnormalities in Ireland.

Aims As part of a cholesterol awareness campaign, we performed a pilot study of current lipid levels to preliminarily assess the extent and pattern of lipid abnormalities in Ireland.

Methods Non-fasting, full lipid profiles and glucose measurements were performed in 259 people (32 on lipid-lowering medication and 225 untreated) using a validated Cholestech LDX machine. Untreated participants included 95 men and 130 women, aged 51 ± 16 years.

Results The mean ± SD, total, low-density lipoprotein (LDL), high-density lipoprotein cholesterol (HDL) and median(IQR) non-HDL cholesterol and triglyceride levels in untreated individuals were 5.0 ± 1.1, 2.8 ± 1.0, 1.5 ± 0.5 and 3.4 (2.8–4.3), 1.6 (1.0–2.3) mmol/l respectively. Glucose was 5.3 (4.8–5.8) mmol/l. Glucose > 7.8 mmol/l occurred in 10 individuals (4%). Using defined criteria for non-fasting lipid levels, 60% of participants had some form of lipid abnormality with a frequency of 47% having a total cholesterol > 5, 35% with LDL > 3.0, 26% with HDL < 1.0/1.2, 33% with triglycerides > 2.0 and 32% with non-HDL cholesterol > 3.9 mmol/l. Three individuals had untreated LDL > 5 mmol/l (i.e. a ratio of 1:75 of those tested) and eight people had HDLc < 0.7 (1:28) and four had triglyceride above 7.3 mmol/l (1:56).

Conclusions This pilot study reveals significant lipid abnormalities which require further larger more detailed lipid studies to assess the true burden of lipid abnormalities in Ireland. Cascade screening and genetic testing of relatives of those with severe lipid abnormalities should be considered.

Keywords Cholesterol · Ireland · Lipid genetic disorders · Lipids · Non-fasting · Screening

Introduction

Hypercholesterolaemia, particularly raised low-density lipoprotein (LDL) cholesterol levels are causally linked with cardiovascular disease [1]. Raised triglyceride levels have a variable relationship with atherosclerosis with intermediate levels being associated with cardiovascular disease [2–6] due to the significant cholesterol content of remnant particles [7], whereas very high triglyceride levels are associated with pancreatitis [8]. Non-HDL cholesterol reflects the risk associated with remnant particles [9]. Low levels of protective HDL cholesterol have long been associated with increased risk of CHD [10]. and increasing interest is now focused on HDL flux as a measure of reverse cholesterol transport [11, 12]. Most of these lipid abnormalities have a genetic basis [13] but they are also influenced by environmental factors [14]. There is some public awareness about total cholesterol levels but very little about lipid patterns that carry different risks.

There has been a steady decline in cardiovascular mortality in Ireland from 1985 to 2006, with 24% being attributed to cholesterol reduction [15]. Currently, cardiovascular disease accounts for 32% of all deaths in Ireland [16]. Average cholesterol levels have fallen from 6.0 mmol/l in the 1980s [17] to 5.1 mmol/l in an older Irish population [18]. This trend exceeds that of other European countries where the average reduction was 0.2 mmol/l [19]. Nonetheless, it is not known which lipoprotein abnormalities exist and what pattern change accounts for the reduced CHD risk. Evaluating the extent and

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pattern of lipid abnormalities in the population would help identify those at risk and help tailor treatment. In an effort to inform individuals about the important cholesterol risk, an awareness campaign was initiated together with a pilot lipid screening project. Our aim was to highlight both the extent and pattern of lipid abnormalities in Ireland so that a definitive population study could be planned.

Methods

Awareness campaign In order to raise awareness about potential cholesterol problems in Ireland, a cycle of the length and breadth of Ireland was undertaken with the cholesterol message highlighted both on national and local media stations along the journey. Lipid testing was performed at five sites, Aughnasheelin, Co. Leitrim; Athlone, Co. Westmeath; Killarney, Co. Kerry; Claremorris, Co. Mayo; and Kilcock, Co. Kildare, in July 2017. The invitation to attend for cholesterol testing was advertised in local newspapers and on local radio. Ethical approval for this study was achieved from Trinity College Dublin and Tallaght Hospital. Following informed consent, subjects who volunteered at the various testing sites filled in a questionnaire and underwent lipid testing (Fig. 1).

Questionnaire Each subject filled out information regarding, age, gender, family history of cholesterol disorders or heart disease, use of lipid lowering medications, presence of other cardiac risk factors, smoking status and alcohol intake per week.

Lipid testing Non-fasting lipid measurements were performed on finger-tip blood samples using a Cholestech LDX machine that we had previously validated to correspond accurately to laboratory values [20]. A full lipid profile including, total cholesterol, triglyceride, HDL cholesterol LDL cholesterol (Freidewald) [21] and non-HDL cholesterol and glucose were determined. Results were produced within 5 minutes.

Handling of results Each subject discussed their results with a consultant or specialist nurse and actions were advised including review by their general practitioners if necessary. All subjects agreed to their anonymized data being included in a publication.

Reference ranges Reference values for non-fasting lipid samples were derived from a large 92,000 Danish Cohort [22] with the following levels applied as being abnormal: total cholesterol > 5.0 mmol/l, triglyceride > 2.0 mmol/l, HDL cholesterol < 1.0 for men and 1.2 mmol/l for women, LDL cholesterol > 3.0 mmol/l, non-HDL cholesterol > 3.9 mmol/l. A random glucose > 11.1 mmol/l was considered abnormal based on guidelines [23].

Statistical analysis

All data were evaluated using JMP 9 software. Descriptive statistics are presented at percentages, means and standard deviations. Statistical significance was calculated using *t* tests for continuous variables and chi-squared tests for categorical variables and set at $p < 0.05$.

Results

Table 1 outlines the characteristics of the participants studied. They have a broad age range from 18 to 92 years, averaging 51 ± 16 years, with significantly more females 58% than males. There was a low prevalence of smoking, hypertension and diabetes in this population. However, there was a family history of heart disease in 40% of participants and a family history of hypercholesterolaemia in 28%. Lipid-lowering therapy was noted in 34 individuals.

The lipid results are outlined in Table 2. Total cholesterol, triglyceride and non-HDL cholesterol and LDL cholesterol levels were significantly higher in older subjects. The greater cholesterol levels in females were solely due to higher HDL cholesterol levels. Seven (21%) out of the 34 treated patients had LDL cholesterol above recommended levels for their disease status. Of note (but not presented in the table), 58% of those over 45 years had total cholesterol levels greater than 5 mmol/l.

Table 3 outlines the lipid and glucose results in the different locations. Those attending Claremorris were the eldest with the youngest groups attending Athlone and Killarney. The main cholesterol differences between locations were due to age differences. However, the overall highest percentage of lipid abnormalities were evident in Athlone subjects despite their young age.

The frequency distribution of lipid abnormalities using defined lipid values and glucose values is demonstrated in Fig. 2. As regards potential genetic disorders of lipid metabolism, three individuals had LDL cholesterol above 5 mmol/l with one (1:225) having an LDL cholesterol of 6.5 mmol/l which may indicate possible familial hypercholesterolaemia. Eight subjects (1:28) had HDL cholesterol less than 0.7 mmol/l. Triglyceride levels exceeded 4.0 mmol/l in 12 subjects and exceeded 7.3 mmol/l in 4 subjects (1:56).

In all, 60% of those studied had some form of lipid abnormality as shown in Fig. 3. Isolated raised LDL cholesterol levels were the most frequent single abnormality followed by isolated raised triglycerides levels. Combination of lipid abnormalities indicating mixed dyslipidaemias accounted for 42% of all noted disorders.

There were significant correlations between age and total cholesterol, $r = 0.29$ $p < 0001$, triglyceride $r = 0.20$, $p < 0.001$, LDL cholesterol $r = 0.31$ $p < 0.0001$, non-HDL cholesterol

Fig. 1 Lipid testing sites

$r = 0.34$, $p < 0.0001$ but age did not correlate with HDL $r = -0.06$ or glucose $r = -0.03$. There was a highly significant inverse correlation between HDL cholesterol levels and triglyceride $r = -0.35$, $P < 0.0001$ and with non-HDL cholesterol levels $r = -0.33$, $p < 0.0001$ in this population. There was significantly higher lipid levels in those with a family history of heart disease than in those without, total cholesterol 5.2 ± 1.1 mmol/l vs 4.8 ± 1.1 mmol/l, $p < 0.01$; LDL cholesterol 2.9 ± 1.0 vs 2.6 ± 1.0 mmol/l respectively. There were no other significant differences in the frequency of lipid abnormalities between those with and without a family history of CHD.

Discussion

This study provided a snapshot of non-fasting lipid levels in an adult Irish population. The cohort studied, albeit small, had a wide age range and more females, which was similar to the Caucasian population in the large UK Health survey, 2015 [24].However, our participants were self-selected based on media advertisement of free lipid testing, and therefore did not represent a randomised stratified sample of the Irish population. Nonetheless, this preliminary examination of Irish lipid levels is concerning given that 60% of individuals had some form of lipid abnormality. This may even be an underestimate of the true incidence of lipid abnormalities as the low level of other cardiovascular risk factors reported suggests a healthier population participated. The average total cholesterol of 5 mmol/l in all participants and 5.3 mmol/l in those over 50 years is in keeping with recent lipid levels reported from the ongoing TILDA study [18]. Our results compare favourably to the higher average cholesterol levels of 6 mmol/l observed in Ireland in the 1980s [17] and the SLAN study [25] in 2007 where 82% of those over 45 years had total cholesterol levels above 5 mmol/l compared to 58% in our population. These findings suggest improving lipid trends in Ireland and compare well to average cholesterol levels of 5.4 mmol/l in the UK, Danish and US populations [22, 24, 26].

Table 1 Characteristic of participants

		Total	Untreated
		$N = 259$	$N = 225$
Age mean ± SD		53 ± 16 years	51 ± 16 years
Male		110 (42%)	95(42%)
Female		149 (58%)	130(58%)*
Smoking			
Yes		28(11%)	23(11%)
No		231(89%)	202(89%)
Alcohol	Units per week		
None	0	83(32%)	68(30%)
Low	< 10 u	112(43%)	102(45%)
Moderate	<15 u F, < 21 u M	38(15%)	32(15%)
High	≥15 u F, ≥ 21 u M	26(10%)	23(10%)
High cholesterol history		66(25%)	37(16%)
Lipid-lowering meds		34(13%)	0(0%)
Diabetes history		8(3%)	4(2%)
Hypertension history		28(11%)	14(6%)
Family history of CHD		107(41%)	91(40%)
Family history of high cholesterol		76(29%)	63(28%)
Known CHD		16(6%)	11(5%)

*$p < 0.05$ Females versus Males

One of the objectives of this pilot study was to provide an initial assessment of the type and severity of lipid abnormalities in Ireland. Using cut-off values recommended from a large Danish cohort study [22], the frequency of lipid abnormalities in our population differed from that of the UK [24] and Denmark [22] where total cholesterol levels exceeded 5 mmol/l in 47, 66 and 72% respectively, with high non-HDL cholesterol levels occurring in 32% of our population compared to 50% in England and Denmark. Nonetheless, triglyceride abnormalities were more common, 33% compared to 27% in the Danes and low HDL cholesterol levels more frequent, 26% compared to 10% in Danes and 12% in England. The latter suggests that while cholesterol levels were lower in our cohort, the pattern of higher triglyceride and lower HDL indicates more metabolic disarray [27] where small dense LDL particles are more likely [28]. Increasing LDL cholesterol levels with age and higher HDL cholesterol levels in females may account for some of the variation observed in the five regions studied. The greater number of lipid disorders in Athlone despite their young age is interesting but numbers were small and would require confirmation in a larger national cholesterol screening program. Such a program would help monitor population trends and also identify those at a particularly high cardiovascular or pancreatitis risk where early intervention could prevent serious morbidity and mortality. However, studies have shown that even if identified, treatment levels in Ireland are inadequate [29–31]. Therefore, screening together with education and knowledge of appropriate lipid targets will be necessary to correct this major atherosclerotic risk factor.

This study also highlighted the potential that significant genetic disorders of lipid metabolism are likely as three individuals had LDL cholesterol above 5 mmol/l. One subject had an LDL cholesterol above 6.5 mmol/l which may indicate possible familial hypercholesterolaemia. If this was due to a monogenic ligand or receptor defect, the risk is likely similar [32] but the life-long high LDL cholesterol exposure would create an increased risk compared to polygenic causes of raised cholesterol [33]. Genetic testing is therefore advisable to help quantify individual's risk exposure. In addition, four individuals had very elevated triglyceride levels and eight had very low HDL cholesterol levels, most likely of genetic origin. These would create independent pancreatitis

Table 2 Non-fasting lipid levels in an Irish population

	Total	Untreated	Untreated < 50 years	Untreated > 50 years	Untreated males	Untreated females
mmol/l	$N = 259$	$N = 225$	$N = 108$	$N = 117$	$N = 95$ (42%)	$N = 130$ (58%)
Total cholesterol	5.0 ± 1.1	5.0 ± 1.1	4.7 ± 1.0	5.3 ± 1.1¶¶	4.8 ± 1.1	5.2 ± 1.1**
Triglyceride	1.6(1.0–2.3)	1.6(1.0–2.3)	1.4 (0.9–2.1)	1.7(1.1–2.4) ¶	2.1 ± 1.4	1.7 ± 1.1
LDL cholesterol	2.8 ± 0.9	2.8 ± 1.0	2.5 ± 0.9	3.1 ± 1.0¶¶	2.7 ± 0.9	2.9 ± 1.0
HDL cholesterol	1.5 ± 0.5	1.5 ± 0.5	1.5 ± 0.5	1.5 ± 0.5	1.2 ± 0.4	1.6 ± 0.4**
Non-HDL cholesterol	3.4(2.8–4.2)	3.4 (2.8–4.3)	3.0(2.5–3.7)	3.8(3.0–4.6) ¶¶	3.5 ± 1.1	3.6 ± 1.1
LDL/HDL	2.2 ± 1.3	2.2 ± 1.3	2.0 ± 1.3	2.4 ± 1.3 ¶	2.5 ± 1.6	2.0 ± 1.1*
Glucose	5.3(4.8–5.9)	5.3 (4.8–5.8)	5.4 (1.01)	5.2(0.99)	5.7 ± 1.3	5.4 ± 0.9

Mean ± SD median (interquartile range)

¶ = $p < 0.05$, < 50 yrs. vs > 50 years

¶¶ = $p < 0.01$

*$p < 0.05$ Males versus Females

**$p < 0.01$

Table 3 Lipid levels in different areas

	N	Age	% Female	Total cholesterol	Triglyceride	LDLc	HDLc	Non-HDLc	Glucose	Lipid abnormality (%)
Athlone	45	43 ± 13	53	4.9 ± 1.1	1.7(1.3)	2.8 ± 1.0	1.3 ± 0.4*	3.7 ± 1.2	5.6 ± 1.0	78
Aughnasheelin	35	51 ± 13	71	4.8 ± 1.1	1.6(1.0)	2.5 ± 0.9	1.5 ± 0.4	3.3 ± 1.1	5.7 ± 1.3	57
Claremorris	64	63 ± 9	64	5.4 ± 1.1*	1.5(1.3)	3.2 ± 1.0*	1.4 ± 0.5	3.9 ± 1.2*	5.3 ± 1.1	77
Kilcock	41	49 ± 17	56	4.8 ± 1.2	1.2(1.0)*	2.3 ± 0.8	1.5 ± 0.5	3.4 ± 1.0	5.6 ± 0.9	59
Killarney	40	42 ± 15	57	4.8 ± 1.2	1.6(1.3)	2.3 ± 0.8	1.5 ± 0.5	3.2 ± 0.9	5.6 ± 1.1	60

Mean ± SD

Median (interquartile range)

*$p < 0.05$ compared to other areas

and cardiovascular risks, and therefore appropriate screening and targeted management are also important in this subgroup. Additional research is required to characterise these abnormalities at a population level.

In summary, 60% of the population studied had significant lipid abnormalities and a number had markedly abnormal lipid levels indicating potential genetic abnormalities that require further investigation. Our findings are hypothesis generating

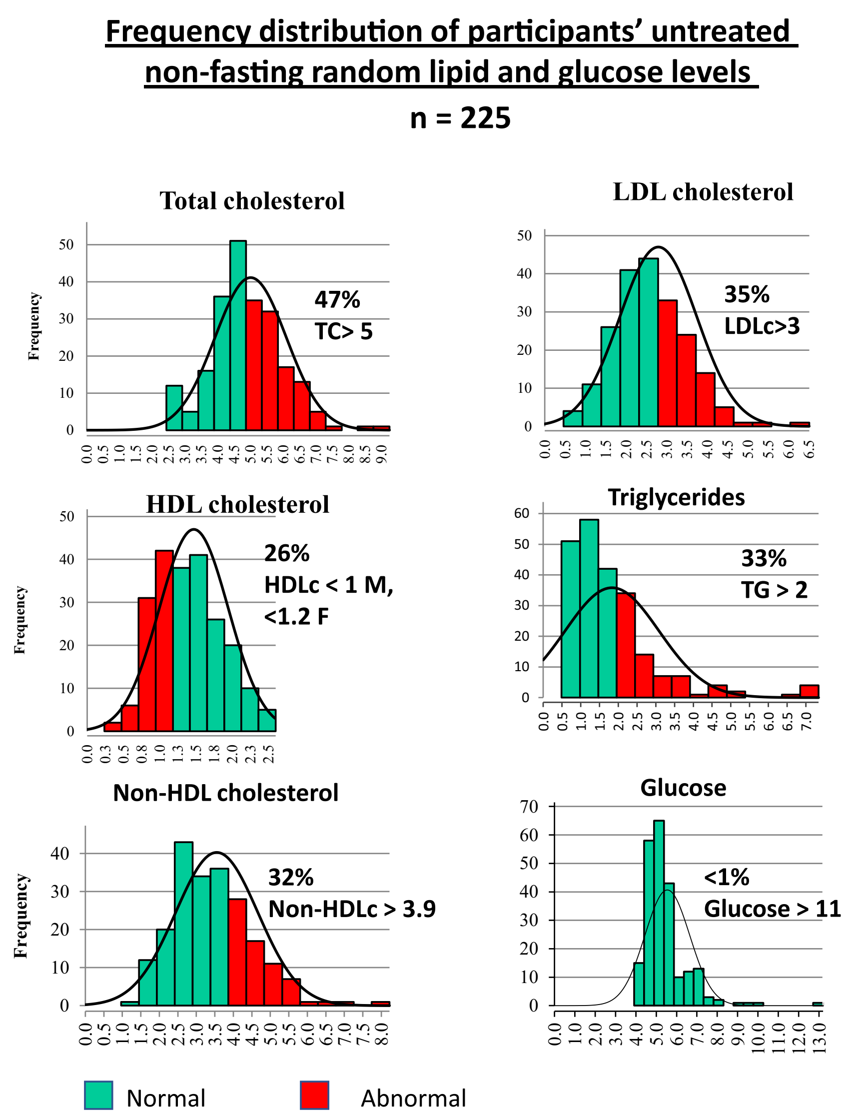

Fig. 2 Frequency distribution of participants' untreated non-fasting random lipid and glucose levels

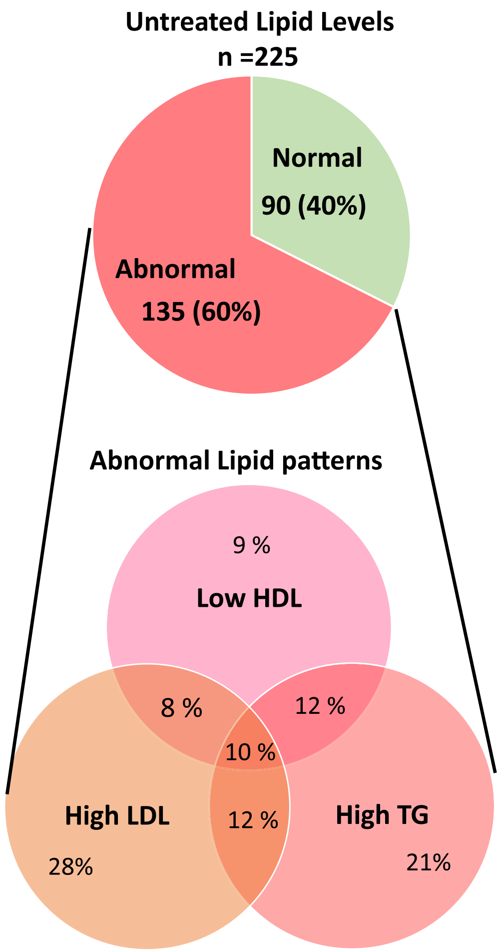

Fig. 3 Untreated lipid levels

and require confirmation in a larger study but are provocative for the need for national lipid screening and targeted genetic studies.

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References

1. Ference BA, Ginsberg HN, Graham I, Ray KK, Packard CJ, Bruckert E, Hegele RA, Krauss RM, Raal FJ, Schunkert H, Watts GF, Borén J, Fazio S, Horton JD, Masana L, Nicholls SJ, Nordestgaard BG, van de Sluis B, Taskinen MR, Tokgözoğlu L, Landmesser U, Laufs U, Wiklund O, Stock JK, Chapman MJ, Catapano AL (2017) Low-density lipoproteins cause atherosclerotic cardiovascular disease. Evidence from genetic, epidemiologic, and clinical studies. A consensus statement from the European Atherosclerosis Society Consensus Panel. Eur Heart J 38:2459–2472. https://doi.org/10.1093/eurheartj/ehx144
2. Berglund L, Brunzell JD, Goldberg AC, Goldberg IJ, Sacks F, Murad MH, Stalenhoef AF, Endocrine society (2012) Evaluation and treatment of hypertriglyceridemia: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab 97:2969–2989
3. Boullart AC, de Graaf J, Stalenhoef AF (2012) Serum triglycerides and risk of cardiovascular disease. Biochim Biophys Acta 1821:867–875
4. Chapman MJ, Ginsberg HN, Amarenco P, Andreotti F, Borén J, Catapano AL, Descamps OS, Fisher E, Kovanen PT, Kuivenhoven JA, Lesnik P, Masana L, Nordestgaard BG, Ray KK, Reiner Z, Taskinen MR, Tokgözoglu L, Tybjærg-Hansen A, Watts GF, for the European Atherosclerosis Society Consensus Panel (2011) Triglyceride-rich lipoproteins and high-density lipoprotein cholesterol in patients at high risk of cardiovascular disease: evidence and guidance for management. Eur Heart J 32:1345–1361
5. Freiberg JJ, Tybjaerg-Hansen A, Jensen JS, Nordestgaard BG (2008) Nonfasting triglycerides and risk of ischemic stroke in the general population. JAMA 300:2142–2152
6. Varbo A, Benn M, Tybjærg-Hansen A, Jørgensen AB, Frikke-Schmidt R, Nordestgaard BG (2013) Remnant cholesterol as a causal risk factor for ischemic heart disease. J Am Coll Cardiol 61(4):427–436. https://doi.org/10.1016/j.jacc.2012.08.1026
7. Hokanson JE, Austin MA (1996) Plasma triglyceride level is a risk factor for cardiovascular disease independent of high-density lipoprotein cholesterol level: a meta-analysis of population-based prospective studies. J Cardiovasc Risk 3:213–219
8. Toskes PP (1990) Hyperlipidaemic pancreatitis. Gastroenterol Clin N Am 19(4):783–791
9. Sniderman AD, Williams K, Contois JH et al., A meta-analysis of low-density lipoprotein cholesterol, non-high-density lipoprotein cholesterol, and apolipoprotein B as markers of cardiovascular risk. Circ Cardiovasc Qual Outcomes 2011;4:337–345.
10. Voight BF, Peloso GM, Orho-Melander M, Frikke-Schmidt R, Barbalic M, Jensen MK, Hindy G, Hólm H, Ding EL, Johnson T, Schunkert H, Samani NJ, Clarke R, Hopewell JC, Thompson JF, Li M, Thorleifsson G, Newton-Cheh C, Musunuru K, Pirruccello JP, Saleheen D, Chen L, Stewart AFR, Schillert A, Thorsteinsdottir U, Thorgeirsson G, Anand S, Engert JC, Morgan T, Spertus J, Stoll M, Berger K, Martinelli N, Girelli D, McKeown PP, Patterson CC, Epstein SE, Devaney J, Burnett MS, Mooser V, Ripatti S, Surakka I, Nieminen MS, Sinisalo J, Lokki ML, Perola M, Havulinna A, de Faire U, Gigante B, Ingelsson E, Zeller T, Wild P, de Bakker PIW, Klungel OH, Maitland-van der Zee AH, Peters BJM, de Boer A, Grobbee DE, Kamphuisen PW, Deneer VHM, Elbers CC, Onland-Moret NC, Hofker MH, Wijmenga C, Verschuren WMM, Boer JMA, van der Schouw YT, Rasheed A, Frossard P, Demissie S, Willer C, Do R, Ordovas JM, Abecasis GR, Boehnke M, Mohlke KL, Daly MJ, Guiducci C, Burtt NP, Surti A, Gonzalez E, Purcell S, Gabriel S, Marrugat J, Peden J, Erdmann J, Diemert P, Willenborg C, König IR, Fischer M, Hengstenberg C, Ziegler A, Buysschaert I, Lambrechts D, van de Werf F, Fox KA, el Mokhtari NE, Rubin D, Schrezenmeir J, Schreiber S, Schäfer A, Danesh J, Blankenberg S, Roberts R, McPherson R, Watkins H, Hall AS, Overvad K, Rimm E, Boerwinkle E, Tybjaerg-Hansen A, Cupples LA, Reilly MP, Melander O, Mannucci PM, Ardissino D, Siscovick D, Elosua R, Stefansson K, O'Donnell CJ, Salomaa V, Rader DJ, Peltonen L, Schwartz SM, Altshuler D, Kathiresan S (2012 Aug 11) Plasma HDL cholesterol and risk of myocardial infarction: a Mendelian randomisation study. Lancet 380(9841):572–580
11. Khera AV, Cuchel M, de la Llera-Moya M et al (2011) Cholesterol efflux capacity, high-density lipoprotein function, and atherosclerosis. N Engl J Med 364:127–135

12. Rohatgi A, Khera A, Berry JD et al., HDL cholesterol efflux capacity and incident cardiovascular events. N Engl J Med 2014;371: 2383–2393.
13. Nordestgaard B, Chapman M, J, Humphries S, for the European Atherosclerosis Society Consensus Panel et al (2013) Familial hypercholesterolaemia is underdiagnosed and undertreated in the general population:guidance for clinicians to prevent coronary heart disease Consensus Statement of the European Atherosclerosis Society. EHJ 34:3478–3490. https://doi.org/10.1093/eurheartj/eht 273
14. Lipids, lipoproteins, and apolipoproteins as risk markers of myocardial infarction in 52 countries (the INTERHEART study): a case-control study. Lancet. 2008 ;372(9634):224–33.
15. Kabir Z, Perry I, Critchley J, O'Flaherty M, Capewell S, Bennett K (2013) Modelling coronary heart disease mortality declines in the Republic of Ireland 1985–2006. Int J Cardiol 2013 Oct 3;168(3): 2462–2467.
16. Central Statistics Office (2013) Vital statistics and fourth quarter and yearly summary 2012. Central Statistics Office, Stationery Office, Dublin
17. Shelley E, Daly L, Collins C, Christie M, Conroy R, Gibney M, Hickey N, Kelleher C, Kilcoyne D, Lee P (1995) Cardiovascular risk factor changes in the Kilkenny Health Project: a community health promotion programme. Eur Heart J 16(6):752–760
18. Murphy C, Shelley E, O'Halloran AM, Fahey T, Kenny RA (2017) Failure to control hypercholesterolaemia in the Irish adult population: cross-sectional analysis of the baseline wave of The Irish Longitudinal Study on Ageing (TILDA). Ir J Med Sci 186:1009–1017. https://doi.org/10.1007/s11845-017-1590-3.
19. Farzadfar F, Finucane MM, Danaei G, Pelizzari PM, Cowan MJ, Paciorek CJ, Singh GM, Lin JK, Stevens GA, Riley LM, Ezzati M (2011) National, regional, and global trends in serum total cholesterol since 1980: systematic analysis of health examination surveys and epidemiological studies with 321 country-years and 3.0 million participants. Lancet 377(9765):578–586
20. M. Carey, C Markham P Gaffney G Boran V Maher Validation of a point of care lipid analyser using a hospital based reference laboratory Dec 2006 Irish Journal of Medical Science
21. Friedewald WT, Levy RI, Fredrickson DS (1972) Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clin Chem 18:499–502
22. Nordestgaard BG, Langsted A, Mora S, Kolovou G, Baum H, Bruckert E, Watts GF, Sypniewska G, Wiklund O, Boren J, Chapman MJ, Cobbaert C, Descamps OS, von Eckardstein A, Kamstrup PR, Pulkki K, Kronenberg F, Remaley AT, Rifai N, Ros E, Langlois M, for the European Atherosclerosis Society (EAS) and the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Joint Consensus Initiative (2016) European Atherosclerosis Society (EAS) and the European Federation of Clinical Chemistry and Laboratory Medicine (EFLM) Joint Consensus Initiative. Fasting Is Not Routinely Required for Determination of a Lipid Profile: Clinical and Laboratory Implications Including Flagging at Desirable Concentration Cutpoints-A Joint Consensus Statement from the European Atherosclerosis Society and European Federation of Clinical Chemistry and Laboratory Medicine. Clin Chem 62(7): 930–946. https://doi.org/10.1373/clinchem.2016.258897
23. Irish College of General Practitioners—A Practical Guide to Integrated Type 2 Care 2016
24. UK Heart Survey NHS The information centre for health and social care (2011) Health Survey for England 2011 Health, social care and lifestyles, Summary of key findings. Department of Health, London
25. Morgan K, McGee H, Watson D et al., (2007) SLAN 2007: Survey of lifestyle, attitudes & nutrition in Ireland. Main report. Department of Health and Children, Dublin
26. Carroll MD, Kit BK, Lacher DA, Shero ST, Mussolino ME (2012) Trends in lipids and lipoproteins in US adults, 1988–2010. JAMA 308(15):1545–1554
27. Leahy S, O'Halloran A, O'Leary N, Healy M, McCormack M, Kenny R, O'Connell J (2015) Prevalence and correlates of diagnosed and undiagnosed type 2 diabetes mellitus and pre-diabetes in older adults: findings from the Irish Longitudinal Study on Ageing (TILDA). Diabetes Res Clin Pract 110:241–249
28. Packard CJ (2006) Small dense low-density lipoprotein and its role as an independent predictor of cardiovascular disease. Curr Opin Lipidol 17:412–417
29. Murphy C, Bennett K, Fahey T, Shelley E, Graham I, Kenny RA (2015) Statin use in adults at high risk of cardiovascular disease mortality: cross-sectional analysis of baseline data from The Irish Longitudinal Study on Ageing (TILDA). BMJ Open 5:e008017. https://doi.org/10.1136/bmjopen-2015-008017
30. Kotseva K, De Bacquer D, De Backer G, On Behalf of the Euroaspire Investigators Lifestyle and risk factor management in people at high risk of cardiovascular disease et al (2016) A report from the European Society of Cardiology European Action on Secondary and Primary Prevention by Intervention to Reduce Events (EUROASPIRE) IV cross-sectional survey in 14 European regions. Eur J Prev Cardiol 23(18):2007–2018. https://doi.org/10.1177/2047487316667784
31. Dunne M, MacAnaney O, Markham C, Maher V (April 2013) Lipid targets in clinical practice: successes, failures and lessons to be learned. Ir J Med Sci 182(4):673–678. https://doi.org/10.1007/s11845-013-0954-6.
32. Maher V, Gallagher J, Thompson G, Myant N (December 1995) Does the presence of the 3500 mutant apolipoprotein B-100 in low density lipoprotein particles affect their atherogenicity? Atherosclerosis 118(1):105–110
33. Khera AV, Won HH, Peloso GM, Lawson KS, Bartz TM, Deng X, van Leeuwen EM, Natarajan P, Emdin CA, Bick AG, Morrison AC, Brody JA, Gupta N, Nomura A, Kessler T, Duga S, Bis JC, van Duijn CM, Cupples LA, Psaty B, Rader DJ, Danesh J, Schunkert H, McPherson R, Farrall M, Watkins H, Lander E, Wilson JG, Correa A, Boerwinkle E, Merlini PA, Ardissino D, Saleheen D, Gabriel S, Kathiresan S (2016 Jun 7) Diagnostic Yield and Clinical Utility of Sequencing Familial Hypercholesterolemia Genes in Patients with Severe Hypercholesterolemia. J Am Coll Cardiol 67(22):2578–2589