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Prevalence of dyslipidaemia and awareness of blood cholesterol levels among community-living people: Results from the Longevity check-up 7+ (Lookup 7+) project

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ABSTRACT

Objective The aim of the present study was to investigate the prevalence of abnormal cholesterol levels and to explore awareness of cholesterol levels in an unselected sample of community-living adults.

Design Cross-sectional survey.

Setting Exhibitions, malls, and health promotion campaigns across Italy.

Participants 3,535 community-dwellers aged 18-98 years were enrolled between September 2016 and June 2017. Analyses were conducted in 3,040 participants, after excluding 495 enrollees on cholesterol-lowering medications.

Main outcome measures Total blood cholesterol levels and awareness of cholesterol values.

Results Abnormal blood cholesterol values were found in 1,961 (64.5%) of participants with no differences between genders (p=0.06). Among those who believed they had normal cholesterol levels, only 48% had values below 200 mg/dL. More than 40% had cholesterol values between 200 and 240 mg/dL, and around 10% had values >240 mg/dL. More than one third of participants had not measured cholesterol in the last year. Among them, only 36% had normal cholesterol levels.

Conclusions Abnormal blood cholesterol is highly prevalent among Italian community-dwellers, with less than half of participants being aware of their cholesterol levels.

Key words: hypercholesterolaemia; primordial prevention; public health; screening; lifestyle; cardiovascular health metrics

Strengths and limitations of this study

- This survey allowed the identification of a high proportion of Italian community-dwellers (approximately two thirds of enrollees) with abnormal blood cholesterol levels. A similar proportion of people that had not checked their cholesterol in the year before the survey was identified.
- Awareness of blood cholesterol levels is low among community-living Italians, with over 50% of participants who believed they had normal cholesterol levels showing abnormal values.
- The Lookup 7+ approach may be used as an easy, reproducible and inexpensive screening strategy to foster public health, especially outside of conventional healthcare settings.
- The use of random cholesterol and glucose determinations could lead to overestimating both parameters.
- The type of evaluation and its setting could influence the assessment of health metrics.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death worldwide and accounts for the largest share of healthcare expenditure in many countries.[1] Despite the prevention strategies adopted in recent decades, CVD still affects one in three adults and causes the same proportion of deaths.[2, 3] Whereas primary and secondary prevention continues to address individuals who have already sustained a cardiovascular event or present with one or more risk factors, primordial prevention is recommended for improving cardiovascular health on a national scale.[4, 5]

Although CVD prevention represents one key action of healthcare programmes, little data are available concerning the awareness about the importance of prevention in the general population. Screening for dyslipidaemia should be considered in all men ≥40 years of age and in women ≥50 years of age or post-menopausal, particularly in the presence of other CVD risk factors. Yet, the prevalence of positive cardiovascular health metrics, including ideal blood cholesterol values, is disappointingly low in the general population.[6] The aims of the present study were to investigate the prevalence of high cholesterol levels and to explore awareness of cholesterol levels in an unselected sample of community-dwellers enrolled in the Longevity Check-up 7+ (Lookup 7+) project.

METHODS

The Lookup 7+ project is an ongoing initiative developed by the Department of Geriatrics of the Catholic University of the Sacred Heart (Rome, Italy). The project started on June 1st 2015 and was designed to promote the adoption of healthier lifestyles by raising awareness in the general population on major lifestyle behaviours and risk factors for chronic diseases. A team of medical doctors, researchers, and nutritionists assessed people visiting public places (e.g., malls, exhibition centres) and those adhering to prevention campaigns launched by our department. This approach was chosen because allowing for enrolling relatively unselected participants, outside of conventional healthcare or research settings. The assessment protocol has been described in detail elsewhere.[6] Candidate participants are considered to be eligible for enrolment if they are at least 18 years of age and provided written informed consent. Pregnancy, inability to perform functional tests, refusal of blood capillary check, and unwillingness to give written informed consent are considered exclusionary. The study protocol was approved by the Catholic University of the Sacred Heart Ethics Committee.

Study sample

As part of the Lookup 7+ initiative, 6,323 individuals in different surveys and Italian cities were enrolled. In the current study, we focused on surveys in which specific questions about the awareness of the importance of CVD prevention were considered. We therefore narrowed the sample to 3,535 individuals enrolled in the following settings: *Mese del Cuore 2016* (Rome, September- October 2016), *La Romanina – Check your Longevity* (Rome, December 2016), *Mese del Cuore 2017* (Milan, March-April 2017), *Health Ministry – Women's Day* (Rome, April 2017), CamBio Vita (Catania, May, 2017), and *COOP shopping centres* (Bologna, Modena, Genova, Rimini, and Grosseto, May-June 2017).

Persons on cholesterol lowering drugs (n=495) were excluded from the analyses. In

principle, individuals who are taking cholesterol medications are already aware of this risk factor and have less of a need to be educated. Therefore, a final sample of 3,040 individuals was considered.

Data collection

The Lookup 7+ visit was structured to collect the following information and data: informed consent, lifestyle interview (smoking and eating habits, habitual physical activity), blood pressure measurement, weight and height assessment, total blood cholesterol and glucose measurements, and the chair stand test. At the end of the assessment, participants were provided with their cardiovascular health metrics score along with suggestions on how to improve their lifestyle and on the eventual need for further assessments.[6, 7]

Total blood cholesterol measurement

Total blood cholesterol was measured from capillary blood samples using disposable reagent strips based on a reflectometric system with a MultiCare-In portable device (Biomedical Systems International srl, Florence, Italy).[8] Before cholesterol measurement, participants were asked two questions about their cholesterol awareness: (1) 'How do you think your cholesterol level is?' with possible answers being: "High", "Normal", or "I do not know"; and (2) 'Did you measure cholesterol in the last year?' with possible answers being "Yes" or "No".

Assessment of other cardiovascular health metrics

Other parameters pertaining to major cardiovascular risk factors were assessed through closed questions and direct measurement.[6, 7] Smoking habit was categorised as current or never/former smoker. Body weight was measured through an analogue medical scale. Body height was measured using a standard stadiometer. Body mass index (BMI) was calculated as the weight

(kg) divided by the square of height (m). Healthy diet was defined as the consumption of at least three portions of fruit and/or vegetables per day.[9] For the calculation of daily intake of fruit and vegetables, we used the reference tables for the Italian population released by the Italian Society of Nutrition (SINU). Accordingly, three or more portions of fruit and/or vegetables correspond to more than 400 g, which is the minimum amount recommended by the World Health Organisation. The use of three or more portions to identify a healthy diet is in line with Italian dietary habits for fruit and vegetables which are typically eaten during the main meals rather than as snacks. Reference amounts are available at http://www.sinu.it/html/cnt/larn.asp. A random blood glucose value was obtained from capillary blood samples using disposable reagent strips based on an amperometric system with the MultiCare-In device.[8] Those who declared being diabetic and, according to international guidelines,[10] those who presented with a random blood glucose level ≥200 mg/dL were considered to be diabetic. Blood pressure was measured with an electronic sphygmomanometer according to recommendations from international guidelines.[11] Participants who declared being hypertensive and those with two systolic blood pressure measurements ≥140 mmHg and/or two diastolic blood pressure values ≥90 mmHg were considered to be hypertensive.[11]

Statistical analyses

Continuous variables are expressed as mean ± standard deviation (SD), categorical variables as frequencies by absolute value and percentages. Descriptive statistics were used to describe demographic and key clinical characteristics of the study population according to gender. Differences in proportions and means of covariates between genders were assessed using the Fisher's exact test and t-test statistics, respectively.

The primary focus of the analytic plan was to explore the prevalence of high blood cholesterol across self-predicted cholesterol levels among individuals who had not checked their

cholesterol in past year. Participants were grouped by blood cholesterol levels [<200 mg/dL (normal); 200-240 mg/dL (moderate high); >240 mg/dL (high)] and age [<45years (young); 45-65 years (middle-aged); >65 years (old)].

Logistic regression analysis was used to assess the association between clinical and lifestyle characteristics and cholesterol awareness. Univariate and adjusted models were performed for self-predicted cholesterol levels and for cholesterol checks in past year. Candidate variables to be included in the logistic regression models were selected on the basis of their plausibility as risk factors for poor cholesterol awareness. We first estimated a crude prevalence rate ratio at 95% confidence interval (CI) and then controlled for age and gender. Finally, logistic regression analyses were computed including all the variables of interest (age, gender, smoking habit, healthy diet, physical activity, BMI, blood pressure, and diabetes).

All analyses were performed using SPSS software (version 11.0, SPSS Inc., Chicago, IL).

RESULTS

Sample characteristics according to gender are shown in Table 1. The mean age of the 3,040 participants was 56.6 years (SD 14.6, range 18-98 years), with 1,858 (61%) women. Men were more frequently physically active than women (59% vs. 53%, respectively; p=0.002). Instead, women were more likely to follow a healthy diet compared with men (68% vs. 59%, respectively; p<0.001). As expected, BMI, systolic and diastolic blood pressure were higher among men. The mean cholesterol level was higher in women than men (215 mg/dL vs. 211 mg/dL, respectively; p<0.001). However, the proportion of participants with normal cholesterol levels was similar in women and men (34% vs. 36%, respectively; p=0.06).

Table 1. General characteristics of study sample according to gender.

Characteristics	**Total sample** (n=3,040)	**Men** (n=1,182)	**Women** (n=1,858)	***p* values**
Age	56.6 ± 14.6	57.1 ± 14.6	56.3 ± 14.5	0.11
Smoking	508 (17)	235 (20)	273 (15)	<0.001
Physically active	1,674 (55)	692 (59)	982 (53)	0.002
Healthy diet	1,958 (63)	698 (57)	1,260 (66)	<0.001
BMI	25.7 ± 4.4	26.7 ± 3.8	25.0 ± 4.7	<0.001
SBP (mmHg)	123 ± 16.4	126 ± 14.8	121 ± 17.1	<0.001
DBP (mmHg)	73 ± 10	76 ± 10	72 ± 10	<0.001
Total blood cholesterol (mg/dL)	213.4 ± 32.2	210.8 ± 32.1	215.1 ± 32.1	<0.001
Cholesterol level categories				
<200 mg/dL	1,079 (36)	439 (37)	640 (34)	0.06
200-240 mg/dL	1,465 (48)	572 (48)	893 (48)	
>240 mg/dL	496 (16)	171 (15)	325 (18)	
Blood glucose (mg/dL)	100.7 ± 20.9	101.7 ± 23.6	100.1 ± 19.1	0.04
Cholesterol check in past year (No)	1,201 (40)	458 (39)	735 (40)	0.66
Self-predicted cholesterol level				
Normal	1,285 (42)	565 (48)	720 (39)	<0.001
High	1,148 (38)	404 (34)	744 (40)	
Don't know	607 (20)	213 (18)	394 (21)	

Data are given as the numbers (percentages) for smoking, physical activity, healthy diet, cholesterol level categories, cholesterol screening and self-predicted cholesterol; for all other

variables, means and standard deviations are reported.

When considering self-predicted cholesterol levels, 48% of men thought they had normal values compared with 39% of women (p<0.001) (Table 1). Figure 1 shows the prevalence of cholesterol levels according to self-predicted values. Among those who believed they had normal cholesterol levels, only 48% showed values below 200 mg/dL. More than 40% had cholesterol values between 200 and 240 mg/dL, and around 10% had values greater than 240 mg/dL. Furthermore, only 38% of participants that were in the "don't know" group had normal cholesterol levels, with no differences between genders (Figure 1).

Factors associated with "normal" self-predicted cholesterol levels are shown in Table 2. In the adjusted model, there was a direct association between female gender [odds ratio (OR) 1.43, 95% CI 1.27-1.73] and normal BMI (OR 1.15, 95% CI 1.01-1.35) with normal self-reported cholesterol.

Table 2. Predictive factors for normal self-predicted cholesterol level.

Variable	**Self-predicted cholesterol "Normal "** (n=1,285)	**Self-predicted cholesterol "High/Don't Know"** (n=1,755)	***Univariate Odds Ratio*** (95% CI)	***Adjusted Odds Ratio*** [#] (95% CI)
Age, years				
<45	297	321	1.0 (Referent)	1.0 (Referent)
45-65	538	901	0.65 (0.54-0.79)	0.67 (0.54-0.82)
>65	450	533	0.90 (0.73-1.10)	0.88 (0.69-1.11)
Gender				
Male	565	617	1.0 (Referent)	1.0 (Referent)
Female	720	1,138	1.44 (1.25-1.67)	1.48 (1.27-1.73)
Smoking habit				
Yes	206	292	1.0 (Referent)	1.0 (Referent)
No	1,079	1,463	1.01 (0.83-1.22)	0.92 (0.75-1.13)
Healthy diet				
No	474	662	1.0 (Referent)	1.0 (Referent)
Yes	811	1,093	1.03 (0.89-1.19)	1.08 (0.93-1.27)
Physically active				
No	591	818	1.0 (Referent)	1.0 (Referent)
Yes	694	937	1.03 (0.89-1.19)	1.00 (0.86-1.16)
BMI				
>25 Kg/m^2	649	914	1.0 (Referent)	1.0 (Referent)
≤25 Kg/m^2	636	841	1.06 (0.92-1.22)	1.15 (1.01-1.35)
Blood pressure *				
High	676	909	1.0 (Referent)	1.0 (Referent)
Normal	579	790	0.99 (0.86-1.15)	1.01 (0.85-1.19)
Diabetes *				
Yes	1,189	1,652	1.0 (Referent)	1.0 (Referent)
No	91	95	0.74 (0.55-1.01)	0.79 (0.58-1.07)

[#] Adjusted simultaneously for all the variables listed

* 86 missing data for blood pressure and 13 missing data for diabetes

Forty percent of participants had not measured cholesterol in past year, with no differences between men and women (39% vs. 40%, respectively, p=0.66) (Table 1). Among these participants, only 36% had normal cholesterol levels (Figure 1). Figure 2 shows the prevalence of cholesterol levels among enrolees who had not checked cholesterol in past year according to age groups. In the middle-age group (45-65 years), a higher prevalence of people with abnormal

cholesterol levels was observed (55% 200-240 mg/dL; 18% >240 mg/dL). The prevalence of abnormal cholesterol levels was significantly higher in women than in men (77% vs. 62%, respectively; $p<0.001$).

Factors associated with no cholesterol screening in past year are shown in Table 3. In the adjusted model, older age was inversely associated with no cholesterol check, indicating that older people were more likely to control this cardiovascular risk factor. Smoking habit (OR 1.38, 95% CI 1.12-1.69) and unhealthy diet (OR 1.39, 95 % CI 1.18-1.63) were directly associated with the absence of cholesterol check in past year.

Table 3. Factors predictive of no cholesterol screening in past year.

Variable	**Cholesterol checked** (n=1,869)	**No cholesterol check** (n=1,171)	***Univariate Odds Ratio*** (95% CI)	***Adjusted Odds Ratio*** [#] (95% CI)
Age, years				
<45	257	357	1.0 (Referent)	1.0 (Referent)
45-65	907	536	0.42 (0.35-0.51)	0.46 (0.37-0.57)
>65	705	278	0.29 (0.24-0.36)	0.36 (0.28-0.47)
Gender				
Female	1,132	726	1.0 (Referent)	2.0 (Referent)
Male	737	445	1.05 (0.90-1.22)	1.11 (0.95-1.31)
Current smoking				
No	1,613	929	1.0 (Referent)	1.0 (Referent)
Yes	256	242	1.58 (1.31-1.92)	1.38 (1.12-1.69)
Healthy diet				
Yes	1,247	657	1.0 (Referent)	1.0 (Referent)
No	622	514	1.54 (1.33-1.79)	1.39 (1.18-1.63)
Physically active				
Yes	1,034	597	1.0 (Referent)	1.0 (Referent)
No	837	574	1.18 (1.02-1.37)	1.09 (0.93-1.28)
BMI				
≤25 Kg/m^2	884	593	1.0 (Referent)	1.0 (Referent)
>25 Kg/m^2	985	578	1.13 (0.98-1.31)	1.04 (0.88-1.22)
Blood pressure *				
Normal	770	599	1.0 (Referent)	1.0 (Referent)
High	1,051	534	0.66 (0.57-0.77)	0.91 (0.77-1.09)
Diabetes *				
No	1,728	1,113	1.0 (Referent)	1.0 (Referent)
Yes	133	53	0.61 (0.44-0.84)	0.73 (0.52-1.03)

Adjusted simultaneously for all the variables listed

* 86 missing data for blood pressure and 13 missing data for diabetes

Finally, we analysed cholesterol levels among participants who had not checked their cholesterol in the past year and believed to have a normal value (n=437). In this subsample, only 198 (45%) persons had normal values, 203 (47%) had cholesterol between 200 and 240 mg/dL, and 36 (8%) had values >240 mg/dL.

DISCUSSION

We explored the prevalence of abnormal cholesterol levels and cholesterol awareness in a large and unselected sample of community-dwelling persons. We also compared rates of awareness and check of cholesterol levels according between age groups and genders.

Overall, abnormal blood cholesterol was highly prevalent in our sample and less than half of individuals were aware of their cholesterol values. Indeed, more than half of participants who believed they had normal cholesterol levels showed abnormal values. Similarly, among those who had not checked cholesterol in the past year (40%), more than half (64%) had abnormal cholesterol levels. This rate was even higher in middle-aged participants (45-64 years) with a prevalence of 73%. Some gender differences were observed, with women who had not checked cholesterol in the past year being more likely to have high values compared with men.

Only 36% of participants had normal cholesterol values, a slightly higher number than in other surveys.[6, 7, 12] This rate is still too low, especially considering the high prevalence of other risk factors potentially modifiable through lifestyle adjustments (i.e., smoking, sedentariness, unhealthy diet) or pharmacological treatments (i.e., cholesterol and blood pressure). Our data show that the 45-64 years age group is particularly critical. Indeed, in this subset, we observed a higher prevalence of uncontrolled cholesterol levels, especially in women. Furthermore, in middle age there is a significantly increased prevalence of all other risk factors, as evidenced by the decline in the cardiovascular health metrics score after younger age.[6, 7] Our data also show that younger individuals, smokers and those with unhealthy diet are at higher risk of not having checked cholesterol in past year.

The burden associated with high blood cholesterol represents a prevalent and growing issue requiring effective preventive policies on a large scale and the planning of short- and long-term goals.[13, 14] Anticipation of risk factor development (i.e., primordial prevention) may be the most effective measure for this purpose. Indeed, blood cholesterol was identified by the American Heart

Association as one of the most important factors to consider.[15] Nevertheless, in Europe, the same long-term policies have been planned in small contexts and little data are available about the prevalence and distribution of cholesterol control and awareness.[16, 17] Several studies examined the awareness of high cholesterol levels in the United States.[18, 19] Our study provides unique data from a large sample about the prevalence of high cholesterol levels and awareness in a European country.

Gaps in cholesterol awareness and screening are often related to availability of, access to, or continuity of healthcare. Public health programmes to raise cholesterol awareness, increase the proportion of cholesterol screening and achieve better cholesterol control are needed. More than half of the reduction in cardiovascular mortality in the last decade has been attributed to population-level changes in risk factors, primarily reductions in cholesterol, blood pressure, and smoking.[20, 21]

Limitations

Some limitations of our study should be considered in the interpretation of results. Random cholesterol and glucose determinations could lead to overestimating both parameters. Conventionally, blood samples for lipid analysis are drawn in the fasting state. However, fasting and non-fasting sampling gives similar results for total cholesterol, LDL-cholesterol and HDL-cholesterol. Cholesterol and glucose were measured in capillary blood samples. Although the procedure was previously validated,[8] the error of portable devices is higher than standard equipment. Only total cholesterol was analysed and no information on LDL- and HDL-cholesterol was available. Nevertheless, total cholesterol is typically used for cardiovascular risk estimation in risk estimation charts. The type of evaluation and its setting could also influence the assessment of health metrics. Indeed, people who decided to participate were involved – before being assessed – in usual exhibition and/or shopping centre activities, such as walking, carrying bags, and eating,

which could have influenced the assessment. Our results were obtained from a cross-sectional survey. As such, some findings could be explained by differences in the birth cohort rather than reflecting true age-related changes. Finally, the Lookup 7+ population included only Caucasians, which impedes the generalisability of our results to other ethnic groups.

Conclusions

In terms of public health and active longevity, adulthood is the most important age for the implementation of specific screening and prevention programmes.[22] The Lookup 7+ is an easy, reproducible and inexpensive screening approach that may be used as a model to promote public health, especially outside of conventional healthcare settings. Through specific programmes such as the Lookup 7+, it is indeed possible to promote awareness about the importance of preventative strategies among persons who otherwise would not undergo any screening.

AUTHOR CONTRIBUTIONS

Conceived and designed the analyses: A.Si., E.M., R.C, and F.L. Analysed the data: A.Si, A.P., and M.T. Coordinated participant recruitment and performed participant assessments: A.M.M., E.O., S.S., and T.P. Drafted the paper: A.Sa. and L.S. Supervised the project and edited the manuscript: R.B. All authors read and approved the final manuscript.

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COMPETING INTERESTS

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no relationships or activities that could appear to have influenced the submitted work.

DATA SHARING

Data will be made available with no restriction upon reasonable request at francesco.landi@unicatt.it.

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The funders had no role in study design, data collection and analysis, preparation of the manuscript, or decision to publish.

ETHICAL APPROVAL

The study protocol was approved by the Catholic University of the Sacred Heart Ethics Committee.

TRANSPARENCY DECLARATION

The authors declare that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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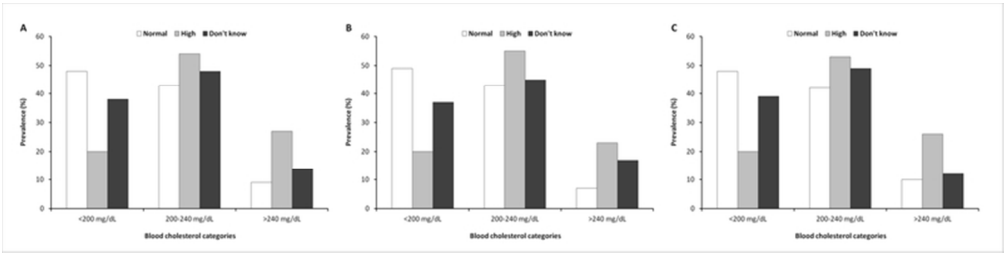
FIGURE LEGENDS

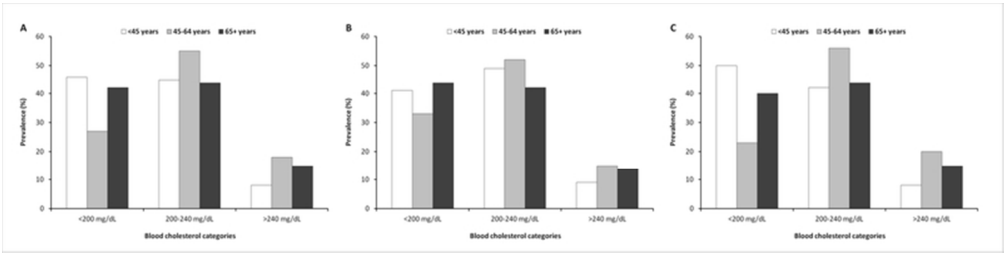
Figure 1. Total blood cholesterol according to self-predicted cholesterol levels in the whole sample (A), in men (B), and in women (C).

Figure 2. Total blood cholesterol levels among participants who did not check cholesterol in past year (n=1,201) according to age groups in the whole sample (A), in men (B), and in women (C).



Total blood cholesterol according to self-predicted cholesterol levels in the whole sample (A), in men (B), and in women (C).

67x16mm (300 x 300 DPI)



Total blood cholesterol levels among participants who did not check cholesterol in past year (n=1,201) according to age groups in the whole sample (A), in men (B), and in women (C).

67x16mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Pg. 1,2**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Pg. 2**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Pg. 4**
Objectives	3	State specific objectives, including any prespecified hypotheses **Pg. 4**
Methods		
Study design	4	Present key elements of study design early in the paper **Pg. 5**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Pg. 5-7**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Pg. 5,6**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Pg. 7,8**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Pg. 6,7**
Bias	9	Describe any efforts to address potential sources of bias **Pg. 8**
Study size	10	Explain how the study size was arrived at **Pg. 4,5**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Pg. 8**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding

	(*b*) Describe any methods used to examine subgroups and interactions **Pg. 7,8**
	(*c*) Explain how missing data were addressed **Pg. 8**
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **N/A**
	(*e*) Describe any sensitivity analyses **N/A**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Pg. 9**
		(b) Give reasons for non-participation at each stage **N/A**
		(c) Consider use of a flow diagram **N/A**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Pg. 9-13**
		(b) Indicate number of participants with missing data for each variable of interest **Pg. 11,13**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **Pg. 9-13**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Pg. 9-13**
		(*b*) Report category boundaries when continuous variables were categorized **Pg.11,12**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **N/A**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Pg. 10-13**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Pg. 14**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Pg. 15,16**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Pg. 14-16**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Pg. 16**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Pg. 17**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence of dyslipidaemia and awareness of blood cholesterol levels among community-living people: Results from the Longevity check-up 7+ (Lookup 7+) project

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Keywords:	hypercholesterolaemia, primordial prevention, PUBLIC HEALTH, screening, lifestyle, cardiovascular health metrics

Prevalence of dyslipidaemia and awareness of blood cholesterol levels among community-living people: Results from the Longevity check-up 7+ (Lookup 7+) project

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ABSTRACT

Objective The aim of the present study was to investigate the prevalence of abnormal cholesterol levels and to explore awareness of cholesterol levels in an unselected sample of community-living adults.

Design Cross-sectional survey.

Setting Exhibitions, malls, and health promotion campaigns across Italy.

Participants 3,535 community-dwellers aged 18-98 years were enrolled between September 2016 and June 2017. Analyses were conducted in 3,040 participants, after excluding 495 enrolees on cholesterol-lowering medications.

Main outcome measures Total blood cholesterol levels and awareness of cholesterol values.

Results Abnormal blood cholesterol values were found in 1,961 (64.5%) of participants with no differences between genders (p=0.06). Among those who believed they had normal cholesterol levels, only 48% had values below 200 mg/dL. More than 40% had cholesterol values between 200 and 240 mg/dL, and around 10% had values >240 mg/dL. More than one third of participants had not measured cholesterol in the last year. Among them, only 36% had normal cholesterol levels.

Conclusions Abnormal blood cholesterol is highly prevalent in our sample of Italian community-dwellers, with less than half of participants being aware of their cholesterol levels.

Key words: hypercholesterolaemia; primordial prevention; public health; screening; lifestyle; cardiovascular health metrics

Strengths and limitations of this study

- This survey allowed the identification of a high proportion of community-dwellers (approximately two thirds of enrolees) with abnormal blood cholesterol levels. A similar proportion of people that had not checked their cholesterol in the year before the survey was identified.
- Awareness of blood cholesterol levels is low in our sample of community-living Italians, with over 50% of participants who believed they had normal cholesterol levels showing abnormal values.
- The Lookup 7+ approach may be used as an easy, reproducible and inexpensive screening strategy to foster public health, especially outside of conventional healthcare settings.
- The use of random cholesterol and glucose determinations could lead to overestimating both parameters.
- The type of evaluation and its setting could influence the assessment of health metrics.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death worldwide and accounts for the largest share of healthcare expenditure in many countries.[1] Despite the prevention strategies adopted in recent decades, CVD still affects one in three adults and causes the same proportion of deaths.[2, 3] Whereas primary and secondary prevention addresses individuals who present with one or more risk factors or have already sustained a cardiovascular event, primordial prevention is recommended for improving cardiovascular health on a national scale.[4, 5]

Although CVD prevention represents one key action of healthcare programmes, little data are available concerning the awareness about the importance of prevention in the general population. Screening for dyslipidaemia should be considered in all men ≥40 years of age and in women ≥50 years of age or post-menopausal, particularly in the presence of other CVD risk factors. Yet, the prevalence of positive cardiovascular health metrics, including ideal blood cholesterol values, is disappointingly low in the general population.[6] The aims of the present study were to investigate the prevalence of high cholesterol levels and to explore awareness of cholesterol levels in an unselected sample of community-dwellers enrolled in the Longevity Check-up 7+ (Lookup 7+) project.

METHODS

The Lookup 7+ project is an ongoing initiative developed by the Department of Geriatrics of the Catholic University of the Sacred Heart (Rome, Italy). The project started on June 1st 2015 and was designed to promote the adoption of healthier lifestyles by raising awareness in the general population on major lifestyle behaviours and risk factors for chronic diseases. A team of medical doctors, researchers, and nutritionists assessed people visiting public places (e.g., malls, exhibition centres) and those adhering to prevention campaigns launched by our department. This approach was chosen because allowing for enrolling relatively unselected participants, outside of conventional healthcare or research settings. The assessment protocol has been described in detail elsewhere.[6] Candidate participants are considered to be eligible for enrolment if they are at least 18 years of age and provided written informed consent. Pregnancy, inability to perform functional tests, refusal of blood capillary check, and unwillingness to give written informed consent are considered exclusionary. The study protocol was approved by the Ethics Committee of the Catholic University of the Sacred Heart.

Participant and public involvement

Although, study participants or public were not formally involved in the design of the study, the questionnaire used for data collection and the specific assessments conducted were developed based on previous experiences in similar surveys.[6–10] Furthermore, at the end of the evaluation, participants were provided with their cardiovascular health metrics score [11] along with suggestions on how to improve their lifestyle and on the eventual need for further assessments. Notably, as previously reported,[10] among 6,323 Lookup 7+ participants, the vast majority (4,917; 82%) declared to be very satisfied with the initiative, 688 (14%) were satisfied, 148 (3%) declared to be neither satisfied nor dissatisfied, and only 49 (1%) were not satisfied.

Study sample

As part of the Lookup 7+ initiative, 6,323 individuals in different surveys and Italian cities were enrolled between June 1st 2015 and June 30th 2017. In the current study, we focused on surveys in which specific questions about the awareness of the importance of CVD prevention were considered. We therefore narrowed the sample to 3,535 individuals enrolled in the following settings: *Mese del Cuore 2016* (Rome, September- October 2016), *La Romanina – Check your Longevity* (Rome, December 2016), *Mese del Cuore 2017* (Milan, March-April 2017), *Health Ministry – Women's Day* (Rome, April 2017), CamBio Vita (Catania, May, 2017), and *COOP shopping centres* (Bologna, Modena, Genoa, Rimini, and Grosseto, May-June 2017). Depending on the setting, the initiative was advertised in newspapers, magazines and TV broadcasting. Visitors were also invited to participate by direct contact.

Persons on cholesterol-lowering drugs (n=495) were excluded from the analyses. In principle, individuals who are taking cholesterol medications are already aware of this risk factor and have less of a need to be educated. Therefore, a final sample of 3,040 individuals was considered.

Data collection

The Lookup 7+ visit was structured to collect the following information and data: informed consent, lifestyle interview (smoking and eating habits, habitual physical activity), blood pressure measurement, weight and height assessment, total blood cholesterol and glucose measurements, and the chair stand test.

Total blood cholesterol measurement

Total blood cholesterol was measured from capillary blood samples using disposable reagent strips based on a reflectometric system with a MultiCare-In portable device (Biomedical

Systems International srl, Florence, Italy).[12] Before cholesterol measurement, participants were asked two questions about their cholesterol awareness: (1) 'How do you think your cholesterol level is?' with possible answers being: "High", "Normal", or "I do not know"; and (2) 'Did you measure cholesterol in the last year?' with possible answers being "Yes" or "No".

Assessment of other cardiovascular health metrics

Other parameters pertaining to major cardiovascular risk factors were assessed through closed questions and direct measurement.[6, 11] Smoking habit was categorised as current or never/former smoker.[10] Body weight was measured through an analogue medical scale. Body height was measured using a standard stadiometer. Body mass index (BMI) was calculated as the weight (kg) divided by the square of height (m). Healthy diet was defined as the consumption of at least three portions of fruit and/or vegetables per day.[8] For the calculation of daily intake of fruit and vegetables, we used the reference tables for the Italian population released by the Italian Society of Nutrition (SINU). Accordingly, three or more portions of fruit and/or vegetables correspond to more than 400 g, which is the minimum amount recommended by the World Health Organisation. The use of three or more portions to identify a healthy diet is in line with Italian dietary habits for fruit and vegetables which are typically eaten during the main meals rather than as snacks. Reference amounts are available at http://www.sinu.it/html/cnt/larn.asp. A random blood glucose value was obtained from capillary blood samples using disposable reagent strips based on an amperometric system with the MultiCare-In device.[12] Those who declared being diabetic and, according to international guidelines,[13] those who presented with a random blood glucose level ≥200 mg/dL were considered to be diabetic. Blood pressure was measured with a clinically validated Omron M6 electronic sphygmomanometer (Omron, Kyoto, Japan), according to recommendations from international guidelines.[14] Participants who declared being hypertensive and those with two systolic blood pressure measurements ≥140 mmHg and/or two diastolic blood

pressure values ≥90 mmHg were considered to be hypertensive.[14]

Statistical analyses

Continuous variables are expressed as mean ± standard deviation (SD), whilst categorical variables are shown as frequencies by absolute value and percentages. Descriptive statistics were used to describe demographic and key clinical characteristics of the study population according to gender. Differences in proportions and means of covariates between genders were assessed using the Fisher's exact test and t-test statistics, respectively.

The primary focus of the analytic plan was to explore the prevalence of high blood cholesterol across self-predicted cholesterol levels among individuals who had not checked their cholesterol in past year. Participants were grouped by blood cholesterol levels [<200 mg/dL (normal); 200-240 mg/dL (moderate high); >240 mg/dL (high)] and age [<45years (young); 45-65 years (middle-aged); >65 years (old)].

Logistic regression analysis was used to assess the association between clinical and lifestyle characteristics and cholesterol awareness. Univariate and adjusted models were performed for self-predicted cholesterol levels and for cholesterol checks in past year. Candidate variables to be included in the logistic regression models were selected on the basis of their plausibility as risk factors for poor cholesterol awareness. We first estimated a crude prevalence rate ratio at 95% confidence interval (CI) and then controlled for age and gender. Finally, logistic regression analyses were computed including all the variables of interest (age, gender, smoking habit, healthy diet, physical activity, BMI, blood pressure, and diabetes).

All analyses were performed using SPSS software (version 18.0, SPSS Inc., Chicago, IL).

RESULTS

Sample characteristics according to gender are shown in Table 1. The mean age of the 3,040 participants was 56.6 years (SD 14.6, range 18-98 years), with 1,858 (61%) women. Men were more frequently physically active than women (59% vs. 53%, respectively; p=0.002). Instead, women were more likely to follow a healthy diet compared with men (68% vs. 59%, respectively; p<0.001). As expected, BMI and systolic and diastolic blood pressure were higher among men. The mean cholesterol level was higher in women than men (215 mg/dL vs. 211 mg/dL, respectively; p<0.001). However, the proportion of participants with normal cholesterol levels was similar in women and men (34% vs. 36%, respectively; p=0.06).

Table 1. General characteristics of study sample according to gender.

Characteristics	**Total sample** (n=3,040)	**Men** (n=1,182)	**Women** (n=1,858)	***p* values**
Age (years)	56.6 ± 14.6	57.1 ± 14.6	56.3 ± 14.5	0.11
Smoking (yes)	508 (17)	235 (20)	273 (15)	<0.001
Physically active (yes)	1,674 (55)	692 (59)	982 (53)	0.002
Healthy diet (yes)	1,958 (63)	698 (57)	1,260 (66)	<0.001
BMI (kg/m^2)	25.7 ± 4.4	26.7 ± 3.8	25.0 ± 4.7	<0.001
SBP (mmHg)	123 ± 16.4	126 ± 14.8	121 ± 17.1	<0.001
DBP (mmHg)	73 ± 10	76 ± 10	72 ± 10	<0.001
Total blood cholesterol (mg/dL)	213.4 ± 32.2	210.8 ± 32.1	215.1 ± 32.1	<0.001
Cholesterol level categories				
<200 mg/dL	1,079 (36)	439 (37)	640 (34)	0.06
200-240 mg/dL	1,465 (48)	572 (48)	893 (48)	
>240 mg/dL	496 (16)	171 (15)	325 (18)	
Blood glucose (mg/dL)	100.7 ± 20.9	101.7 ± 23.6	100.1 ± 19.1	0.04
Cholesterol check in past year (no)	1,201 (40)	458 (39)	735 (40)	0.66
Self-predicted cholesterol level				
Normal	1,285 (42)	565 (48)	720 (39)	<0.001
High	1,148 (38)	404 (34)	744 (40)	
Don't know	607 (20)	213 (18)	394 (21)	

Data are given as numbers (percentages) for smoking, physical activity, healthy diet, cholesterol level categories, cholesterol screening and self-predicted cholesterol; for all other variables, means

and standard deviations are reported. *Abbreviations*: BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure

When considering self-predicted cholesterol levels, 48% of men thought they had normal values compared with 39% of women ($p<0.001$) (Table 1). Figure 1 shows the prevalence of cholesterol levels according to self-predicted values. Among those who believed they had normal cholesterol levels, only 48% showed values <200 mg/dL. More than 40% had cholesterol values between 200 and 240 mg/dL, and around 10% had values >240 mg/dL. Furthermore, only 38% of participants that were in the "don't know" group had normal cholesterol levels, with no differences between genders (Figure 1).

Factors associated with "normal" self-predicted cholesterol levels are shown in Table 2. In the adjusted model, there was a direct association between female gender [odds ratio (OR) 1.43, 95% CI 1.27-1.73] and normal BMI (OR 1.15, 95% CI 1.01-1.35) with normal self-reported cholesterol.

Table 2. Factors predictive of normal self-predicted cholesterol level.

Variable	**Self-predicted cholesterol "Normal "** (n=1,285)	**Self-predicted cholesterol "High/Don't Know"** (n=1,755)	***Univariate Odds Ratio*** (95% CI)	***Adjusted Odds Ratio*** [#] (95% CI)
Age, years				
<45	297	321	1.0 (Referent)	1.0 (Referent)
45-65	538	901	0.65 (0.54-0.79)	0.67 (0.54-0.82)
>65	450	533	0.90 (0.73-1.10)	0.88 (0.69-1.11)
Gender				
Male	565	617	1.0 (Referent)	1.0 (Referent)
Female	720	1,138	1.44 (1.25-1.67)	1.48 (1.27-1.73)
Current smoking				
Yes	206	292	1.0 (Referent)	1.0 (Referent)
No	1,079	1,463	1.01 (0.83-1.22)	0.92 (0.75-1.13)
Healthy diet				
No	474	662	1.0 (Referent)	1.0 (Referent)
Yes	811	1,093	1.03 (0.89-1.19)	1.08 (0.93-1.27)
Physically active				
No	591	818	1.0 (Referent)	1.0 (Referent)
Yes	694	937	1.03 (0.89-1.19)	1.00 (0.86-1.16)
BMI, kg/m^2				
≥25	649	914	1.0 (Referent)	1.0 (Referent)
<25	636	841	1.06 (0.92-1.22)	1.15 (1.01-1.35)
Blood pressure *				
High	676	909	1.0 (Referent)	1.0 (Referent)
Normal	579	790	0.99 (0.86-1.15)	1.01 (0.85-1.19)
Diabetes *				
Yes	1,189	1,652	1.0 (Referent)	1.0 (Referent)
No	91	95	0.74 (0.55-1.01)	0.79 (0.58-1.07)

[#] Adjusted simultaneously for all the variables listed

* 86 missing data for blood pressure and 13 missing data for diabetes

Abbreviation: BMI, body mass index

Forty percent of participants had not measured cholesterol in past year, with no differences between men and women (39% vs. 40%, respectively, p=0.66) (Table 1). Among these participants, only 36% had normal cholesterol levels (Figure 1). Figure 2 shows the prevalence of cholesterol levels among enrolees who had not checked cholesterol in past year according to age

groups. In the middle age group (45-64 years), a higher prevalence of people with abnormal cholesterol levels was observed (55% 200-240 mg/dL; 18% >240 mg/dL). The prevalence of abnormal cholesterol levels was significantly higher in women than in men (77% vs. 62%, respectively; $p<0.001$).

Factors associated with no cholesterol screening in past year are shown in Table 3. In the adjusted model, older age was inversely associated with no cholesterol check, indicating that older people were more likely to control this cardiovascular risk factor. Current smoking (OR 1.38, 95% CI 1.12-1.69) and unhealthy diet (OR 1.39, 95 % CI 1.18-1.63) were directly associated with the absence of cholesterol check in past year.

Table 3. Factors predictive of no cholesterol screening in past year.

Variable	**Cholesterol checked** (n=1,869)	**No cholesterol check** (n=1,171)	***Univariate Odds Ratio*** (95% CI)	***Adjusted Odds Ratio*** [#] (95% CI)
Age, years				
<45	257	357	1.0 (Referent)	1.0 (Referent)
45-65	907	536	0.42 (0.35-0.51)	0.46 (0.37-0.57)
>65	705	278	0.29 (0.24-0.36)	0.36 (0.28-0.47)
Gender				
Female	1,132	726	1.0 (Referent)	2.0 (Referent)
Male	737	445	1.05 (0.90-1.22)	1.11 (0.95-1.31)
Current smoking				
No	1,613	929	1.0 (Referent)	1.0 (Referent)
Yes	256	242	1.58 (1.31-1.92)	1.38 (1.12-1.69)
Healthy diet				
Yes	1,247	657	1.0 (Referent)	1.0 (Referent)
No	622	514	1.54 (1.33-1.79)	1.39 (1.18-1.63)
Physically active				
Yes	1,034	597	1.0 (Referent)	1.0 (Referent)
No	837	574	1.18 (1.02-1.37)	1.09 (0.93-1.28)
BMI, kg/m^2				
<25	884	593	1.0 (Referent)	1.0 (Referent)
≥25	985	578	1.13 (0.98-1.31)	1.04 (0.88-1.22)
Blood pressure *				
Normal	770	599	1.0 (Referent)	1.0 (Referent)
High	1,051	534	0.66 (0.57-0.77)	0.91 (0.77-1.09)
Diabetes *				
No	1,728	1,113	1.0 (Referent)	1.0 (Referent)
Yes	133	53	0.61 (0.44-0.84)	0.73 (0.52-1.03)

[#] Adjusted simultaneously for all the variables listed

* 86 missing data for blood pressure and 13 missing data for diabetes

Abbreviation: BMI, body mass index

Finally, we analysed cholesterol levels among participants who had not checked their cholesterol in the past year and believed to have a normal value (n=437). In this subsample, only 198 (45%) persons had normal values, 203 (47%) had cholesterol between 200 and 240 mg/dL, and 36 (8%) had values >240 mg/dL.

DISCUSSION

We explored the prevalence of abnormal cholesterol levels and cholesterol awareness in a large and unselected sample of community-dwelling persons. We also compared rates of awareness and check of cholesterol levels between age groups and genders.

Overall, abnormal blood cholesterol was highly prevalent in our sample and less than half of individuals were aware of their cholesterol values. Indeed, more than half of participants who believed they had normal cholesterol levels showed abnormal values. Similarly, among those who had not checked cholesterol in the past year (40%), more than half (64%) had abnormal cholesterol levels. This rate was even higher in middle-aged participants (45-64 years) with a prevalence of 73%. Some gender differences were observed, with women who had not checked cholesterol in the past year being more likely to have high values compared with men.

Only 36% of participants had normal cholesterol values. The same prevalence was determined in a large sample of unselected Italian community-dwellers.[15] This rate is disappointingly low, especially considering the high prevalence of other risk factors potentially modifiable through lifestyle adjustments (i.e., smoking, sedentariness, and unhealthy diet) or pharmacological treatments (i.e., cholesterol and blood pressure). The prevalence of dyslipidaemia unawareness in the Lookup 7+ sample (52%) was strikingly similar to that found in a previous small-scale Italian survey (56.9%),[16] but it was higher than in the NHANES survey (49%).[17] It should however be noted that the latter study also included participants on cholesterol-lowering medications, who may be expected to have better knowledge of their blood lipid profile. In contrast, enrolees on lipid-lowering drugs were excluded from the present analysis. Our data show that the 45-64 years age group is particularly critical. Indeed, in this subset, we observed a higher prevalence of uncontrolled cholesterol levels, especially in women. This observation is in line with the NHANES survey, in which the 45-64 years age group showed the highest blood cholesterol levels.[17] Similar to previous observations,[15] this age group is also characterised by the lowest

prevalence of cholesterol awareness. Furthermore, in middle age there is a significantly increased prevalence of all other risk factors, as evidenced by the decline in the cardiovascular health metrics score after younger age.[6, 11] Finally, in keeping with previous surveys,[15–17] our data show that younger individuals, smokers and those on unhealthy diet are at higher risk of not having checked cholesterol in past year.

The burden associated with high blood cholesterol represents a prevalent and growing issue requiring effective preventive policies on a large scale and the planning of short- and long-term goals. Anticipation of risk factor development (i.e., primordial prevention) may be the most effective measure for this purpose. Indeed, blood cholesterol was identified by the American Heart Association as one of the most important factors to consider.[18] Nevertheless, in Europe, the same long-term policies have been planned in small contexts and little data are available about the prevalence and distribution of cholesterol control and awareness.[19, 20]

Our findings together with those of previous studies indicate that new public health strategies that go beyond simple, often disregarded lifestyle recommendations are necessary to improve cardiovascular health at the population level.[21] Indeed, gaps in cholesterol awareness and screening are often related to availability of, access to, or continuity of healthcare. Public health programmes to raise cholesterol awareness, increase the proportion of cholesterol screening, and achieve better cholesterol control are needed. To this aim, the Lookup 7+ initiative may represent a prototypical approach to promote the recognition and management of unhealthy behaviours and modifiable cardiovascular risk factors in the general population.

Limitations

Some limitations of our study should be considered in the interpretation of results. Random cholesterol and glucose determinations could lead to overestimating both parameters. Conventionally, blood samples for lipid analysis are drawn in the fasting state. However, fasting

and non-fasting sampling gives similar results for total cholesterol, LDL-cholesterol and HDL-cholesterol. Cholesterol and glucose were measured in capillary blood samples. Although the procedure was previously validated,[12] the error of portable devices is higher than with standard equipment. Only total cholesterol was analysed and no information on LDL- and HDL-cholesterol was available. Nevertheless, total cholesterol is typically used for cardiovascular risk estimation in CVD risk prediction charts. The type of evaluation and its setting could also influence the assessment of health metrics. Indeed, people who decided to participate were involved – before being assessed – in usual exhibition and/or shopping centre activities, such as walking, carrying bags, and eating, which could have influenced the assessment. Furthermore, alcohol and coffee drinking, which may affect blood pressure and blood lipids levels, was not recorded or controlled for. In order not to overburden the participants and keep the duration of evaluations within a reasonable time range, waist circumference, which is considered to be a better indicator of abdominal fatness and CVD than BMI, was not measured. However, BMI has shown to be predictive of cardiovascular events in the context of multivariable prediction algorithms.[22] Because information on socioeconomic characteristics and education was not collected, the impact of social status and health literacy on cardiovascular risk awareness could not be established. Our results were obtained from a cross-sectional survey. As such, some findings could be explained by differences in the birth cohort rather than reflecting true age-related patterns. Finally, the Lookup 7+ population included only Caucasians, which impedes the generalisability of our results to other ethnic groups.

CONCLUSIONS

In terms of public health and active longevity, adulthood is the most important age for the implementation of specific screening and prevention programmes.[23] The Lookup 7+ is an easy, reproducible and relatively inexpensive screening approach that may be used as a model to

promote public health, especially outside of conventional healthcare settings. Through specific programmes such as the Lookup 7+, it is indeed possible to promote awareness about the importance of preventative strategies among persons who otherwise would not undergo any screening.

AUTHOR CONTRIBUTIONS

Conceived and designed the analyses: A.Si., E.M., R.C, and F.L. Analysed the data: A.Si, A.P., and M.T. Coordinated participant recruitment and performed participant assessments: A.M.M., E.O., S.S., and T.P. Drafted the paper: A.Sa. and L.S. Supervised the project and edited the manuscript: R.B. All authors read and approved the final manuscript.

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COMPETING INTERESTS

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no relationships or activities that could appear to have influenced the submitted work.

DATA SHARING

Data will be made available with no restriction upon reasonable request at francesco.landi@unicatt.it.

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2015) to F.L. and by the non-profit research foundation "Centro Studi Achille e Linda Lorenzon" (A.P., E.M., R.C.).

The funders had no role in study design, data collection and analysis, preparation of the manuscript, or decision to publish.

ETHICAL APPROVAL

The study protocol was approved by the Catholic University of the Sacred Heart Ethics Committee.

TRANSPARENCY DECLARATION

The authors declare that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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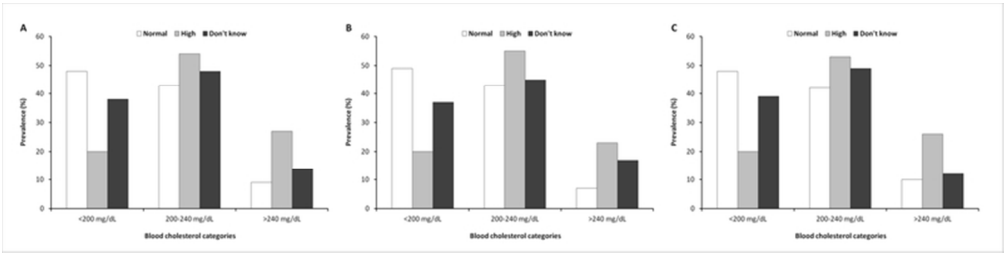
FIGURE LEGENDS

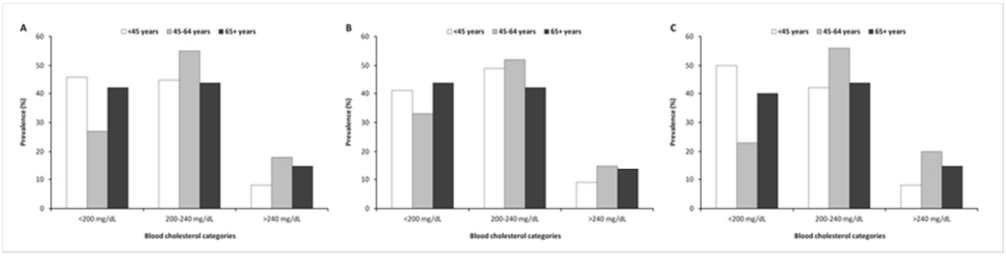
Figure 1. Total blood cholesterol according to self-predicted cholesterol levels in the whole sample (A), in men (B), and in women (C).

Figure 2. Total blood cholesterol levels among participants who did not check cholesterol in past year (n=1,201) according to age groups in the whole sample (A), in men (B), and in women (C).



Total blood cholesterol according to self-predicted cholesterol levels in the whole sample (A), in men (B), and in women (C).

67x16mm (300 x 300 DPI)



Total blood cholesterol levels among participants who did not check cholesterol in past year (n=1,201) according to age groups in the whole sample (A), in men (B), and in women (C).

67x16mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Pg. 1,2**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Pg. 2**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Pg. 4**
Objectives	3	State specific objectives, including any prespecified hypotheses **Pg. 4**
Methods		
Study design	4	Present key elements of study design early in the paper **Pg. 5**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Pg. 5-7**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Pg. 5,6**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Pg. 7,8**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Pg. 6,7**
Bias	9	Describe any efforts to address potential sources of bias **Pg. 8**
Study size	10	Explain how the study size was arrived at **Pg. 4,5**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Pg. 8**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding

	(*b*) Describe any methods used to examine subgroups and interactions **Pg. 7,8**
	(*c*) Explain how missing data were addressed **Pg. 8**
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **N/A**
	(*e*) Describe any sensitivity analyses **N/A**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Pg. 9**
		(b) Give reasons for non-participation at each stage **N/A**
		(c) Consider use of a flow diagram **N/A**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Pg. 9-13**
		(b) Indicate number of participants with missing data for each variable of interest **Pg. 11,13**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **Pg. 9-13**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Pg. 9-13**
		(*b*) Report category boundaries when continuous variables were categorized **Pg.11,12**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **N/A**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Pg. 10-13**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Pg. 14**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Pg. 15,16**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Pg. 14-16**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Pg. 16**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Pg. 17**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence of dyslipidaemia and awareness of blood cholesterol levels among community-living people: Results from the Longevity check-up 7+ (Lookup 7+) cross-sectional survey

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Secondary Subject Heading:	Epidemiology, Cardiovascular medicine
Keywords:	hypercholesterolaemia, primordial prevention, PUBLIC HEALTH, screening, lifestyle, cardiovascular health metrics

Prevalence of dyslipidaemia and awareness of blood cholesterol levels among community-living people: Results from the Longevity check-up 7+ (Lookup 7+) cross-sectional survey

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ABSTRACT

Objective The aim of the present study was to investigate the prevalence of abnormal cholesterol levels and to explore awareness of cholesterol levels in an unselected sample of community-living adults.

Design Cross-sectional survey.

Setting Exhibitions, malls, and health promotion campaigns across Italy.

Participants 3,535 community-dwellers aged 18-98 years were enrolled between September 2016 and June 2017. Analyses were conducted in 3,040 participants, after excluding 495 enrolees on cholesterol-lowering medications.

Main outcome measures Total blood cholesterol levels and awareness of cholesterol values.

Results Abnormal blood cholesterol values were found in 1,961 (64.5%) of participants with no differences between genders (p=0.06). Among those who believed they had normal cholesterol levels, only 48% had values below 200 mg/dL. More than 40% had cholesterol values between 200 and 240 mg/dL, and around 10% had values >240 mg/dL. More than one third of participants had not measured cholesterol in the last year. Among them, only 36% had normal cholesterol levels.

Conclusions Abnormal blood cholesterol is highly prevalent in our sample of Italian community-dwellers, with less than half of participants being aware of their cholesterol levels.

Key words: hypercholesterolaemia; primordial prevention; public health; screening; lifestyle; cardiovascular health metrics

Strengths and limitations of this study

- The unconventional setting in which the research was carried out and the very few exclusion criteria adopted allowed recruitment of "real-world" people across a wide age spectrum.
- The questionnaire used for data collection and the specific assessments conducted were developed based on previous experiences in similar surveys.
- Study variables, including cardiovascular health metrics, were collected through a standardised questionnaire and objective measurements.
- The use of random cholesterol and glucose determinations could lead to overestimating both parameters.
- The type of evaluation and its setting could influence the assessment of health metrics.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death worldwide and accounts for the largest share of healthcare expenditure in many countries.[1] Despite the prevention strategies adopted in recent decades, CVD still affects one in three adults and causes the same proportion of deaths.[2, 3] Whereas primary and secondary prevention addresses individuals who present with one or more risk factors or have already sustained a cardiovascular event, primordial prevention is recommended for improving cardiovascular health on a national scale.[4, 5]

Although CVD prevention represents one key action of healthcare programmes, little data are available concerning the awareness about the importance of prevention in the general population. Screening for dyslipidaemia should be considered in all men ≥40 years of age and in women ≥50 years of age or post-menopausal, particularly in the presence of other CVD risk factors. Yet, the prevalence of positive cardiovascular health metrics, including ideal blood cholesterol values, is disappointingly low in the general population.[6] The aims of the present study were to investigate the prevalence of high cholesterol levels and to explore awareness of cholesterol levels in an unselected sample of community-dwellers enrolled in the Longevity Check-up 7+ (Lookup 7+) project.

METHODS

The Lookup 7+ project is an ongoing initiative developed by the Department of Geriatrics of the Catholic University of the Sacred Heart (Rome, Italy). The project started on June 1st 2015 and was designed to promote the adoption of healthier lifestyles by raising awareness in the general population on major lifestyle behaviours and risk factors for chronic diseases. A team of medical doctors, researchers, and nutritionists assessed people visiting public places (e.g., malls, exhibition centres) and those adhering to prevention campaigns launched by our department. This approach was chosen because allowing for enrolling relatively unselected participants, outside of conventional healthcare or research settings. The assessment protocol has been described in detail elsewhere.[6] Candidate participants are considered to be eligible for enrolment if they are at least 18 years of age and provided written informed consent. Pregnancy, inability to perform functional tests, refusal of blood capillary check, and unwillingness to give written informed consent are considered exclusionary. The study protocol was approved by the Ethics Committee of the Catholic University of the Sacred Heart.

Participant and public involvement

Although, study participants or public were not formally involved in the design of the study, the questionnaire used for data collection and the specific assessments conducted were developed based on previous experiences in similar surveys.[6–10] Furthermore, at the end of the evaluation, participants were provided with their cardiovascular health metrics score [11] along with suggestions on how to improve their lifestyle and on the eventual need for further assessments. Notably, as previously reported,[10] among 6,323 Lookup 7+ participants, the vast majority (4,917; 82%) declared to be very satisfied with the initiative, 688 (14%) were satisfied, 148 (3%) declared to be neither satisfied nor dissatisfied, and only 49 (1%) were not satisfied.

Study sample

As part of the Lookup 7+ initiative, 6,323 individuals in different surveys and Italian cities were enrolled between June 1st 2015 and June 30th 2017. In the current study, we focused on surveys in which specific questions about the awareness of the importance of CVD prevention were considered. We therefore narrowed the sample to 3,535 individuals enrolled in the following settings: *Mese del Cuore 2016* (Rome, September- October 2016), *La Romanina – Check your Longevity* (Rome, December 2016), *Mese del Cuore 2017* (Milan, March-April 2017), *Health Ministry – Women's Day* (Rome, April 2017), CamBio Vita (Catania, May, 2017), and *COOP shopping centres* (Bologna, Modena, Genoa, Rimini, and Grosseto, May-June 2017). Depending on the setting, the initiative was advertised in newspapers, magazines and TV broadcasting. Visitors were also invited to participate by direct contact.

Persons on cholesterol-lowering drugs (n=495) were excluded from the analyses. In principle, individuals who are taking cholesterol medications are already aware of this risk factor and have less of a need to be educated. Therefore, a final sample of 3,040 individuals was considered.

Data collection

The Lookup 7+ visit was structured to collect the following information and data: informed consent, lifestyle interview (smoking and eating habits, habitual physical activity), blood pressure measurement, weight and height assessment, total blood cholesterol and glucose measurements, and the chair stand test.

Total blood cholesterol measurement

Total blood cholesterol was measured from capillary blood samples using disposable reagent strips based on a reflectometric system with a MultiCare-In portable device (Biomedical

Systems International srl, Florence, Italy).[12] Before cholesterol measurement, participants were asked two questions about their cholesterol awareness: (1) 'How do you think your cholesterol level is?' with possible answers being: "High", "Normal", or "I do not know"; and (2) 'Did you measure cholesterol in the last year?' with possible answers being "Yes" or "No".

Assessment of other cardiovascular health metrics

Other parameters pertaining to major cardiovascular risk factors were assessed through closed questions and direct measurement.[6, 11] Smoking habit was categorised as current or never/former smoker.[10] Body weight was measured through an analogue medical scale. Body height was measured using a standard stadiometer. Body mass index (BMI) was calculated as the weight (kg) divided by the square of height (m). Healthy diet was defined as the consumption of at least three portions of fruit and/or vegetables per day.[8] For the calculation of daily intake of fruit and vegetables, we used the reference tables for the Italian population released by the Italian Society of Nutrition (SINU). Accordingly, three or more portions of fruit and/or vegetables correspond to more than 400 g, which is the minimum amount recommended by the World Health Organisation. The use of three or more portions to identify a healthy diet is in line with Italian dietary habits for fruit and vegetables which are typically eaten during the main meals rather than as snacks. Reference amounts are available at http://www.sinu.it/html/cnt/larn.asp. A random blood glucose value was obtained from capillary blood samples using disposable reagent strips based on an amperometric system with the MultiCare-In device.[12] Those who declared being diabetic and, according to international guidelines,[13] those who presented with a random blood glucose level ≥200 mg/dL were considered to be diabetic. Blood pressure was measured with a clinically validated Omron M6 electronic sphygmomanometer (Omron, Kyoto, Japan), according to recommendations from international guidelines.[14] Participants who declared being hypertensive and those with two systolic blood pressure measurements ≥140 mmHg and/or two diastolic blood

pressure values ≥90 mmHg were considered to be hypertensive.[14]

Statistical analyses

Continuous variables are expressed as mean ± standard deviation (SD), whilst categorical variables are shown as frequencies by absolute value and percentages. Descriptive statistics were used to describe demographic and key clinical characteristics of the study population according to gender. Differences in proportions and means of covariates between genders were assessed using the Fisher's exact test and t-test statistics, respectively.

The primary focus of the analytic plan was to explore the prevalence of high blood cholesterol across self-predicted cholesterol levels among individuals who had not checked their cholesterol in past year. Participants were grouped by blood cholesterol levels [<200 mg/dL (normal); 200-240 mg/dL (moderate high); >240 mg/dL (high)] and age [<45years (young); 45-65 years (middle-aged); >65 years (old)].

Logistic regression analysis was used to assess the association between clinical and lifestyle characteristics and cholesterol awareness. Univariate and adjusted models were performed for self-predicted cholesterol levels and for cholesterol checks in past year. Candidate variables to be included in the logistic regression models were selected on the basis of their plausibility as risk factors for poor cholesterol awareness. We first estimated a crude prevalence rate ratio at 95% confidence interval (CI) and then controlled for age and gender. Finally, logistic regression analyses were computed including all the variables of interest (age, gender, smoking habit, healthy diet, physical activity, BMI, blood pressure, and diabetes).

All analyses were performed using SPSS software (version 18.0, SPSS Inc., Chicago, IL).

RESULTS

Sample characteristics according to gender are shown in Table 1. The mean age of the 3,040 participants was 56.6 years (SD 14.6, range 18-98 years), with 1,858 (61%) women. Men were more frequently physically active than women (59% vs. 53%, respectively; p=0.002). Instead, women were more likely to follow a healthy diet compared with men (68% vs. 59%, respectively; p<0.001). As expected, BMI and systolic and diastolic blood pressure were higher among men. The mean cholesterol level was higher in women than men (215 mg/dL vs. 211 mg/dL, respectively; p<0.001). However, the proportion of participants with normal cholesterol levels was similar in women and men (34% vs. 36%, respectively; p=0.06).

Table 1. General characteristics of study sample according to gender.

Characteristics	**Total sample** (n=3,040)	**Men** (n=1,182)	**Women** (n=1,858)	***p* values**
Age (years)	56.6 ± 14.6	57.1 ± 14.6	56.3 ± 14.5	0.11
Smoking (yes)	508 (17)	235 (20)	273 (15)	<0.001
Physically active (yes)	1,674 (55)	692 (59)	982 (53)	0.002
Healthy diet (yes)	1,958 (63)	698 (57)	1,260 (66)	<0.001
BMI (kg/m^2)	25.7 ± 4.4	26.7 ± 3.8	25.0 ± 4.7	<0.001
SBP (mmHg)	123 ± 16.4	126 ± 14.8	121 ± 17.1	<0.001
DBP (mmHg)	73 ± 10	76 ± 10	72 ± 10	<0.001
Total blood cholesterol (mg/dL)	213.4 ± 32.2	210.8 ± 32.1	215.1 ± 32.1	<0.001
Cholesterol level categories				
<200 mg/dL	1,079 (36)	439 (37)	640 (34)	0.06
200-240 mg/dL	1,465 (48)	572 (48)	893 (48)	
>240 mg/dL	496 (16)	171 (15)	325 (18)	
Blood glucose (mg/dL)	100.7 ± 20.9	101.7 ± 23.6	100.1 ± 19.1	0.04
Cholesterol check in past year (no)	1,201 (40)	458 (39)	735 (40)	0.66
Self-predicted cholesterol level				
Normal	1,285 (42)	565 (48)	720 (39)	<0.001
High	1,148 (38)	404 (34)	744 (40)	
Don't know	607 (20)	213 (18)	394 (21)	

Data are given as numbers (percentages) for smoking, physical activity, healthy diet, cholesterol level categories, cholesterol screening and self-predicted cholesterol; for all other variables, means

and standard deviations are reported. *Abbreviations*: BMI, body mass index; DBP, diastolic blood pressure; SBP, systolic blood pressure

When considering self-predicted cholesterol levels, 48% of men thought they had normal values compared with 39% of women ($p<0.001$) (Table 1). Figure 1 shows the prevalence of cholesterol levels according to self-predicted values. Among those who believed they had normal cholesterol levels, only 48% showed values <200 mg/dL. More than 40% had cholesterol values between 200 and 240 mg/dL, and around 10% had values >240 mg/dL. Furthermore, only 38% of participants that were in the "don't know" group had normal cholesterol levels, with no differences between genders (Figure 1).

Factors associated with "normal" self-predicted cholesterol levels are shown in Table 2. In the adjusted model, there was a direct association between female gender [odds ratio (OR) 1.43, 95% CI 1.27-1.73] and normal BMI (OR 1.15, 95% CI 1.01-1.35) with normal self-reported cholesterol.

Table 2. Factors predictive of normal self-predicted cholesterol level.

Variable	**Self-predicted cholesterol "Normal "** (n=1,285)	**Self-predicted cholesterol "High/Don't Know"** (n=1,755)	***Univariate Odds Ratio*** (95% CI)	***Adjusted Odds Ratio*** [#] (95% CI)
Age, years				
<45	297	321	1.0 (Referent)	1.0 (Referent)
45-65	538	901	0.65 (0.54-0.79)	0.67 (0.54-0.82)
>65	450	533	0.90 (0.73-1.10)	0.88 (0.69-1.11)
Gender				
Male	565	617	1.0 (Referent)	1.0 (Referent)
Female	720	1,138	1.44 (1.25-1.67)	1.48 (1.27-1.73)
Current smoking				
Yes	206	292	1.0 (Referent)	1.0 (Referent)
No	1,079	1,463	1.01 (0.83-1.22)	0.92 (0.75-1.13)
Healthy diet				
No	474	662	1.0 (Referent)	1.0 (Referent)
Yes	811	1,093	1.03 (0.89-1.19)	1.08 (0.93-1.27)
Physically active				
No	591	818	1.0 (Referent)	1.0 (Referent)
Yes	694	937	1.03 (0.89-1.19)	1.00 (0.86-1.16)
BMI, kg/m^2				
≥25	649	914	1.0 (Referent)	1.0 (Referent)
<25	636	841	1.06 (0.92-1.22)	1.15 (1.01-1.35)
Blood pressure *				
High	676	909	1.0 (Referent)	1.0 (Referent)
Normal	579	790	0.99 (0.86-1.15)	1.01 (0.85-1.19)
Diabetes *				
Yes	1,189	1,652	1.0 (Referent)	1.0 (Referent)
No	91	95	0.74 (0.55-1.01)	0.79 (0.58-1.07)

[#] Adjusted simultaneously for all the variables listed

* 86 missing data for blood pressure and 13 missing data for diabetes

Abbreviation: BMI, body mass index

Forty percent of participants had not measured cholesterol in past year, with no differences between men and women (39% vs. 40%, respectively, p=0.66) (Table 1). Among these participants, only 36% had normal cholesterol levels (Figure 1). Figure 2 shows the prevalence of cholesterol levels among enrolees who had not checked cholesterol in past year according to age

groups. In the middle age group (45-64 years), a higher prevalence of people with abnormal cholesterol levels was observed (55% 200-240 mg/dL; 18% >240 mg/dL). The prevalence of abnormal cholesterol levels was significantly higher in women than in men (77% vs. 62%, respectively; $p<0.001$).

Factors associated with no cholesterol screening in past year are shown in Table 3. In the adjusted model, older age was inversely associated with no cholesterol check, indicating that older people were more likely to control this cardiovascular risk factor. Current smoking (OR 1.38, 95% CI 1.12-1.69) and unhealthy diet (OR 1.39, 95 % CI 1.18-1.63) were directly associated with the absence of cholesterol check in past year.

Table 3. Factors predictive of no cholesterol screening in past year.

Variable	**Cholesterol checked** (n=1,869)	**No cholesterol check** (n=1,171)	***Univariate Odds Ratio*** (95% CI)	***Adjusted Odds Ratio*** [#] (95% CI)
Age, years				
<45	257	357	1.0 (Referent)	1.0 (Referent)
45-65	907	536	0.42 (0.35-0.51)	0.46 (0.37-0.57)
>65	705	278	0.29 (0.24-0.36)	0.36 (0.28-0.47)
Gender				
Female	1,132	726	1.0 (Referent)	2.0 (Referent)
Male	737	445	1.05 (0.90-1.22)	1.11 (0.95-1.31)
Current smoking				
No	1,613	929	1.0 (Referent)	1.0 (Referent)
Yes	256	242	1.58 (1.31-1.92)	1.38 (1.12-1.69)
Healthy diet				
Yes	1,247	657	1.0 (Referent)	1.0 (Referent)
No	622	514	1.54 (1.33-1.79)	1.39 (1.18-1.63)
Physically active				
Yes	1,034	597	1.0 (Referent)	1.0 (Referent)
No	837	574	1.18 (1.02-1.37)	1.09 (0.93-1.28)
BMI, kg/m^2				
<25	884	593	1.0 (Referent)	1.0 (Referent)
≥25	985	578	1.13 (0.98-1.31)	1.04 (0.88-1.22)
Blood pressure *				
Normal	770	599	1.0 (Referent)	1.0 (Referent)
High	1,051	534	0.66 (0.57-0.77)	0.91 (0.77-1.09)
Diabetes *				
No	1,728	1,113	1.0 (Referent)	1.0 (Referent)
Yes	133	53	0.61 (0.44-0.84)	0.73 (0.52-1.03)

[#] Adjusted simultaneously for all the variables listed

* 86 missing data for blood pressure and 13 missing data for diabetes

Abbreviation: BMI, body mass index

Finally, we analysed cholesterol levels among participants who had not checked their cholesterol in the past year and believed to have a normal value (n=437). In this subsample, only 198 (45%) persons had normal values, 203 (47%) had cholesterol between 200 and 240 mg/dL, and 36 (8%) had values >240 mg/dL.

DISCUSSION

We explored the prevalence of abnormal cholesterol levels and cholesterol awareness in a large and unselected sample of community-dwelling persons. We also compared rates of awareness and check of cholesterol levels between age groups and genders.

Overall, abnormal blood cholesterol was highly prevalent in our sample and less than half of individuals were aware of their cholesterol values. Indeed, more than half of participants who believed they had normal cholesterol levels showed abnormal values. Similarly, among those who had not checked cholesterol in the past year (40%), more than half (64%) had abnormal cholesterol levels. This rate was even higher in middle-aged participants (45-64 years) with a prevalence of 73%. Some gender differences were observed, with women who had not checked cholesterol in the past year being more likely to have high values compared with men.

Only 36% of participants had normal cholesterol values. The same prevalence was determined in a large sample of unselected Italian community-dwellers.[15] This rate is disappointingly low, especially considering the high prevalence of other risk factors potentially modifiable through lifestyle adjustments (i.e., smoking, sedentariness, and unhealthy diet) or pharmacological treatments (i.e., cholesterol and blood pressure). The prevalence of dyslipidaemia unawareness in the Lookup 7+ sample (52%) was strikingly similar to that found in a previous small-scale Italian survey (56.9%),[16] but it was higher than in the NHANES survey (49%).[17] It should however be noted that the latter study also included participants on cholesterol-lowering medications, who may be expected to have better knowledge of their blood lipid profile. In contrast, enrolees on lipid-lowering drugs were excluded from the present analysis. Our data show that the 45-64 years age group is particularly critical. Indeed, in this subset, we observed a higher prevalence of uncontrolled cholesterol levels, especially in women. This observation is in line with the NHANES survey, in which the 45-64 years age group showed the highest blood cholesterol levels.[17] Similar to previous observations,[15] this age group is also characterised by the lowest

prevalence of cholesterol awareness. Furthermore, in middle age there is a significantly increased prevalence of all other risk factors, as evidenced by the decline in the cardiovascular health metrics score after younger age.[6, 11] Finally, in keeping with previous surveys,[15–17] our data show that younger individuals, smokers and those on unhealthy diet are at higher risk of not having checked cholesterol in past year.

The burden associated with high blood cholesterol represents a prevalent and growing issue requiring effective preventive policies on a large scale and the planning of short- and long-term goals. Anticipation of risk factor development (i.e., primordial prevention) may be the most effective measure for this purpose. Indeed, blood cholesterol was identified by the American Heart Association as one of the most important factors to consider.[18] Nevertheless, in Europe, the same long-term policies have been planned in small contexts and little data are available about the prevalence and distribution of cholesterol control and awareness.[19, 20]

Our findings together with those of previous studies indicate that new public health strategies that go beyond simple, often disregarded lifestyle recommendations are necessary to improve cardiovascular health at the population level.[21] Indeed, gaps in cholesterol awareness and screening are often related to availability of, access to, or continuity of healthcare. Public health programmes to raise cholesterol awareness, increase the proportion of cholesterol screening, and achieve better cholesterol control are needed. To this aim, the Lookup 7+ initiative may represent a prototypical approach to promote the recognition and management of unhealthy behaviours and modifiable cardiovascular risk factors in the general population.

Limitations

Some limitations of our study should be considered in the interpretation of results. Random cholesterol and glucose determinations could lead to overestimating both parameters. Conventionally, blood samples for lipid analysis are drawn in the fasting state. However, fasting

and non-fasting sampling gives similar results for total cholesterol, LDL-cholesterol and HDL-cholesterol. Cholesterol and glucose were measured in capillary blood samples. Although the procedure was previously validated,[12] the error of portable devices is higher than with standard equipment. Only total cholesterol was analysed and no information on LDL- and HDL-cholesterol was available. Nevertheless, total cholesterol is typically used for cardiovascular risk estimation in CVD risk prediction charts. The type of evaluation and its setting could also influence the assessment of health metrics. Indeed, people who decided to participate were involved – before being assessed – in usual exhibition and/or shopping centre activities, such as walking, carrying bags, and eating, which could have influenced the assessment. Furthermore, alcohol and coffee drinking, which may affect blood pressure and blood lipids levels, was not recorded or controlled for. In order not to overburden the participants and keep the duration of evaluations within a reasonable time range, waist circumference, which is considered to be a better indicator of abdominal fatness and CVD than BMI, was not measured. However, BMI has shown to be predictive of cardiovascular events in the context of multivariable prediction algorithms.[22] Because information on socioeconomic characteristics and education was not collected, the impact of social status and health literacy on cardiovascular risk awareness could not be established. Our results were obtained from a cross-sectional survey. As such, some findings could be explained by differences in the birth cohort rather than reflecting true age-related patterns. Finally, the Lookup 7+ population included only Caucasians, which impedes the generalisability of our results to other ethnic groups.

CONCLUSIONS

In terms of public health and active longevity, adulthood is the most important age for the implementation of specific screening and prevention programmes.[23] The Lookup 7+ is an easy, reproducible and relatively inexpensive screening approach that may be used as a model to

promote public health, especially outside of conventional healthcare settings. Through specific programmes such as the Lookup 7+, it is indeed possible to promote awareness about the importance of preventative strategies among persons who otherwise would not undergo any screening.

AUTHOR CONTRIBUTIONS

Conceived and designed the analyses: A.Si., E.M., R.C, and F.L. Analysed the data: A.Si, A.P., and M.T. Coordinated participant recruitment and performed participant assessments: A.M.M., E.O., S.S., and T.P. Drafted the paper: A.Sa. and L.S. Supervised the project and edited the manuscript: R.B. All authors read and approved the final manuscript.

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COMPETING INTERESTS

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no relationships or activities that could appear to have influenced the submitted work.

DATA SHARING

Data will be made available with no restriction upon reasonable request at francesco.landi@unicatt.it.

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The funders had no role in study design, data collection and analysis, preparation of the manuscript, or decision to publish.

ETHICAL APPROVAL

The study protocol was approved by the Catholic University of the Sacred Heart Ethics Committee.

TRANSPARENCY DECLARATION

The authors declare that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

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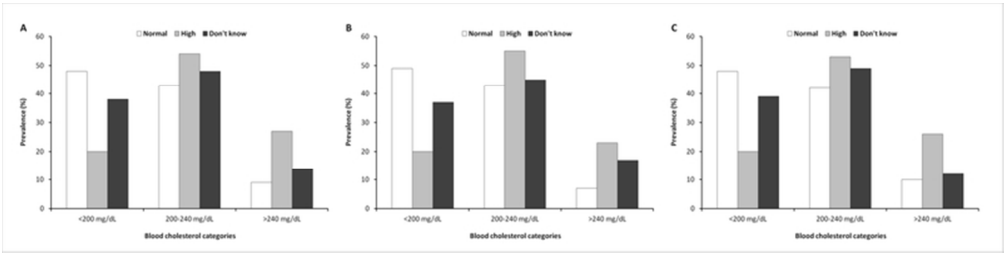
FIGURE LEGENDS

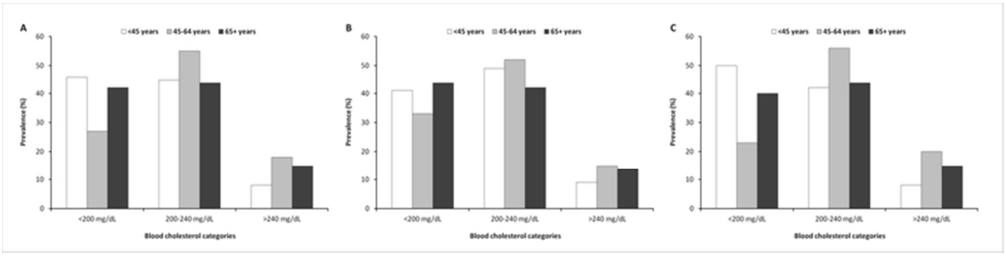
Figure 1. Total blood cholesterol according to self-predicted cholesterol levels in the whole sample (A), in men (B), and in women (C).

Figure 2. Total blood cholesterol levels among participants who did not check cholesterol in past year (n=1,201) according to age groups in the whole sample (A), in men (B), and in women (C).



Total blood cholesterol according to self-predicted cholesterol levels in the whole sample (A), in men (B), and in women (C).

67x16mm (300 x 300 DPI)



Total blood cholesterol levels among participants who did not check cholesterol in past year (n=1,201) according to age groups in the whole sample (A), in men (B), and in women (C).

67x16mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Pg. 1,2**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Pg. 2**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Pg. 4**
Objectives	3	State specific objectives, including any prespecified hypotheses **Pg. 4**
Methods		
Study design	4	Present key elements of study design early in the paper **Pg. 5**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Pg. 5-7**
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants **Pg. 5,6**
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Pg. 7,8**
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **Pg. 6,7**
Bias	9	Describe any efforts to address potential sources of bias **Pg. 8**
Study size	10	Explain how the study size was arrived at **Pg. 4,5**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Pg. 8**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding

	(*b*) Describe any methods used to examine subgroups and interactions **Pg. 7,8**
	(*c*) Explain how missing data were addressed **Pg. 8**
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy **N/A**
	(*e*) Describe any sensitivity analyses **N/A**

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **Pg. 9**
		(b) Give reasons for non-participation at each stage **N/A**
		(c) Consider use of a flow diagram **N/A**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Pg. 9-13**
		(b) Indicate number of participants with missing data for each variable of interest **Pg. 11,13**
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures **Pg. 9-13**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included **Pg. 9-13**
		(*b*) Report category boundaries when continuous variables were categorized **Pg.11,12**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **N/A**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Pg. 10-13**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Pg. 14**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **Pg. 15,16**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Pg. 14-16**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Pg. 16**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **Pg. 17**

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.