BMC Cardiovascular Disorders

RESEARCH

Open Access

Prevalence and factors associated with cardiometabolic multimorbidity: a cross-sectional study in older adults of the first Brazilian hypertension registry

Sandro Rogério Rodrigues Batista[1,2*], Leandro Ferreira Martins[1,2], Priscila Valverde Vitorino de Oliveira[2,3], Andréa Araújo Brandão[4], Eduardo Costa Duarte Barbosa[5], Audes Diógenes M Feitosa[6], Marcus Vinícius Bolivar Malachias[7], Marco Mota Gomes[8], Celso Amodeo[9], Rui Manoel dos Santos Póvoa[10], Renato Delascio Lopes[11], Paulo César Brandão Veiga Jardim[1,2], Ana Luiza Lima Sousa[2,12], Weimar Kunz Sebba Barroso[1,2] and The first Brazilian Hypertension Registry (BHR) investigators

Abstract

Background Cardiometabolic multimorbidity (CM-MM) is defined as the coexistence of at least two of the following conditions: diabetes mellitus (DM), myocardial infarction (MI), or stroke (ST). Data on the prevalence of CM-MM and its associated factors are scarce in Brazil.

Objectives To analyse the prevalence of CM-MM and its associated factors in a population of Brazilian adults aged ≥ 65 years with hypertension.

Methods We conducted an analytical cross-sectional study from 2013 to 2015 using data from the first Brazilian Hypertension Registry (BHR). Participants were recruited from 45 public and private healthcare services in all regions of Brazil. CM-MM was the main outcome measure, analysed according to clinical and sociodemographic factors. Descriptive and association analyses were performed to compare CM-MM and the other parameters.

Results We analysed data from 1,033 individuals. The prevalence of CM-MM was 8.9%, with higher rates among males, participants self-declared as White, and those in the 65–69 years age group. DM (32.7%) was the most prevalent single condition. Dyslipidaemia (70.7%), obesity (62%), and uncontrolled blood pressure (44.6%) were also common. Among the combinations of conditions, DM + MI was the most frequent (5.6%). After adjustment, CM-MM was associated with being male, having dyslipidaemia, experiencing heart failure, and undergoing coronary artery bypass graft surgery. Chronic kidney disease was not associated with CM-MM.

*Correspondence:
Sandro Rogério Rodrigues Batista
sandrorbatista@ufg.br

Full list of author information is available at the end of the article

Conclusions The prevalence of CM-MM in older people with hypertension was approximately 9%. CM-MM was associated with risk factors such as dyslipidaemia and obesity. These findings show the importance of comprehensive cardiometabolic management to reduce the incidence of CM-MM in this population.

Keywords Multimorbidity, Chronic diseases, Hypertension, Elderly people, Cardiovascular disease

Introduction

The growing burden of non-communicable diseases (NCDs), especially in low- and middle-income countries (LMICs), highlights the urgent need to readjust care models for managing these conditions [1, 2]. Among these NCDs, cardiometabolic conditions, including hypertension, dyslipidaemia, coronary heart disease, heart failure, and diabetes mellitus, can independently or collectively, simultaneously, or sequentially lead to complications affecting multiple organs and systems. These complications reduce the quality of life of the patients, increase the use of healthcare services, and escalate associated costs [3–5]. This burden is exponentially exacerbated by the complex contemporary scenario of accelerated population ageing, the accumulation of NCDs, and social inequities [6, 7].

In older adults, cardiovascular disease often occurs in the context of multimorbidity, as the frequency and complexity of concurrent clinical conditions typically increase with older age [8]. Cardiometabolic multimorbidity (CM-MM), defined as the coexistence of at least two of the following cardiometabolic conditions (DM, MI, or ST [9]), is highly prevalent and significantly influences negative health outcomes. CM-MM predominantly affects adults aged > 50 years in high-, middle-, and low-income countries [10, 11]. The prevalence of CM-MM varies significantly between countries. Although there is no standardised method for operationalise CM-MM, recent studies have reported rates of 3.5% in Canada, 4.7% in the United Kingdom and Sweden, 5.94% in China, 10.5% in South Africa, 27.6% in Mexico, and 14.4% in the United States, with significant differences according to age and sex [12–18].

Socioeconomic, demographic, and lifestyle factors play crucial roles in the development of CM-MM [19, 20]. Age, sex, and socioeconomic status are significant predictors of CM-MM onset and progression, particularly in older, female, Black, and poorer individuals [21, 22]. Other studies have indicated that smoking, physical inactivity, unhealthy diets, and inadequate sleep are associated with an increased risk of CM-MM onset [15, 23]. In addition, CM-MM often occurs in individuals with hypertension [23].

Individuals living with CM-MM experience various outcomes, including a significant reduction in life expectancy (up to 12 years for those with two morbidities and up to 15 years for those with three) [9]. They are also at higher risk of all-cause mortality [9, 24, 25] and mortality from coronary heart disease in Black individuals [24]. There is also a significant association between CM-MM and depression and other mood disorders [26, 27]. Furthermore, CM-MM has been associated with accelerated cognitive decline and faster progression of dementia [28–31].

Understanding the dynamics of CM-MM in the Brazilian population is essential to advance epidemiological knowledge on this condition. This understanding will facilitate the development of personalised, population-based intervention strategies to effectively prevent and manage CM-MM in patients with hypertension. To the best of our knowledge, this is the first Brazilian study to analyse the occurrence of CM-MM and its associated factors in a specific population, providing valuable insights for a better understanding. Therefore, this study aimed to analyse the prevalence and factors associated with CM-MM in Brazilian adults aged ≥ 65 years with hypertension.

Methods

This national multicentre analytical cross-sectional study analysed data from the Brazilian Hypertension Registry (BHR). The BHR, an initiative of the Department of Hypertension of the Brazilian Society of Cardiology, recruited participants between June 2013 and October 2015, with follow-up extending until December 2016 [32, 33]. The participating centres represented all five regions of Brazil and included public (46.7%), private (31.1%), and mixed (22.2%) institutions. The BHR was approved by the Research Ethics Committee of the Hospital das Clínicas of the Federal University of Goiás, under protocol number 532,146.

The inclusion criteria for the BHR were as follows: age ≥ 18 years and a diagnosis of hypertension at least 4 weeks before, with systolic blood pressure (SBP) ≥ 140 mmHg and/or diastolic blood pressure (DBP) ≥ 90 mmHg in the sitting position or use of antihypertensive medication, according to the VI Brazilian Hypertension Guidelines [34]. The individual also needed to be regularly enrolled at the participating centre or institution. The exclusion criteria were as follows: kidney failure requiring dialysis, hospitalisation at the time of inclusion or 30 days before, haemodynamic instability requiring vasoactive medications up to 30 days before inclusion, heart failure classified as functional class III or IV, pregnancy and/or breastfeeding, severe Liver disease, psychiatric conditions preventing protocol compliance, ST or

MI within 30 days before inclusion, severe diseases as assessed by the investigator, or neoplasms with a prognosis of survival of less than 1 year.

Data were collected from 2,646 individuals with hypertension using a form developed specifically for BHR, which contained questions about sociodemographic and health characteristics. With the purpose of enhancing the robustness of our data and minimising potential recall biases, we carried out personal interviews and patient records research to cross-verify participant responses. Only participants aged ≥ 65 years were included in this analysis, totalling 1,033 individuals. CM-MM was the primary outcome measure, defined as the coexistence of at least two of the following conditions in the same individual: DM, MI, or ST [9]. These conditions were identified by self-report and/or confirmation in medical records.

The following exposure variables were analysed: sex (male, female), age group (65–69, 70–74, ≥ 75 years), self-reported race (White, Brown, Black), controlled blood pressure (yes, no), health issues (dyslipidaemia, coronary artery bypass graft surgery, heart failure, and chronic kidney disease), obesity (body mass index (BMI) ≥ 30 kg/m^2), physical activity (≥ 3 times a week), current smoking (yes/no), and alcohol use disorder (yes/no). Details on the organisation of variables and data are available in specific studies [32, 33].

Statistical analysis was performed using Stata software version 15.2 (StataCorp LLC., College Station, Texas, USA). Categorical variables were described as absolute and relative frequencies. In bivariate analysis, associations between categorical variables were assessed using the chi-square test, with p-values < 0.05 being associated with the outcome. A simple logistic regression was performed to identify the variables associated with CM-MM. Multiple logistic regression was performed using the stepwise method, including variables with $p > 0.20$ and at least ten individuals in each category. All tests were carried out at a 5% significance level (type 1 error) with 95% confidence intervals.

Results

The average age of 1,033 participants was 71.6 years (interquartile range (IQR), 67.9–76.8), with the majority being female (59.7%), between 65 and 69 years (39.6%), and self-declared White (59.8%). Dyslipidaemia was present in 51.2% of the participants, obesity in 55.8%, and uncontrolled blood pressure in 48.4% (Table 1).

The prevalence of CM-MM was 8.9% ($n = 92$). Table 1 highlights that individuals with CM-MM were predominantly male (60.9%), between 65 and 69 years old (53.3%), and White (65.2%). Dyslipidaemia, obesity, and uncontrolled blood pressure were observed in 70.7%, 62%, and 44.6% of the sample, respectively. The relative frequencies of morbidities and their combinations, as defined by CM-MM, are illustrated in Fig. 1.

Among the associated factors analysed, being male more than doubled the probability of developing CM-MM, as did having dyslipidaemia, heart failure, and a history of coronary artery bypass graft surgery

Table 1 Description of the general sample according to the presence of CM-MM in the first BHR

	Total (*n* = 1,033)		**CM-MM**			
			No (*n* = 941)		**Yes (*n* = 92)**	
Sex	n	%	n	%	n	%
Female	617	59.7	581	61.7	36	39.1
Male	416	40.3	360	38.3	56	60.9
Age group (years)						
65–69	409	39.6	360	38.3	49	53.3
70–74	285	27.6	265	28.2	20	21.7
≥75	339	32.8	316	33.6	23	25
Colour (self-declared)						
White	618	59.8	558	59.3	60	65.2
Brown	231	22.4	211	22.4	20	21.7
Black	184	17.8	172	18.3	12	13
Dyslipidaemia	529	51.2	464	49.3	65	70.7
Myocardial revascularisation	96	9.3	74	7.9	22	23.9
Heart failure	66	6.4	54	5.7	12	13
Chronic kidney disease	44	4.3	37	3.9	7	7.6
Uncontrolled blood pressure	500	48.4	459	48.8	41	44.6
Obesity	576	55.8	519	55.2	57	62
Physical activity	392	37.9	359	38.2	33	35.9
Smoking	40	3.9	36	3.8	4	4.3
Alcohol use disorder	49	4.7	45	4.8	4	4.3

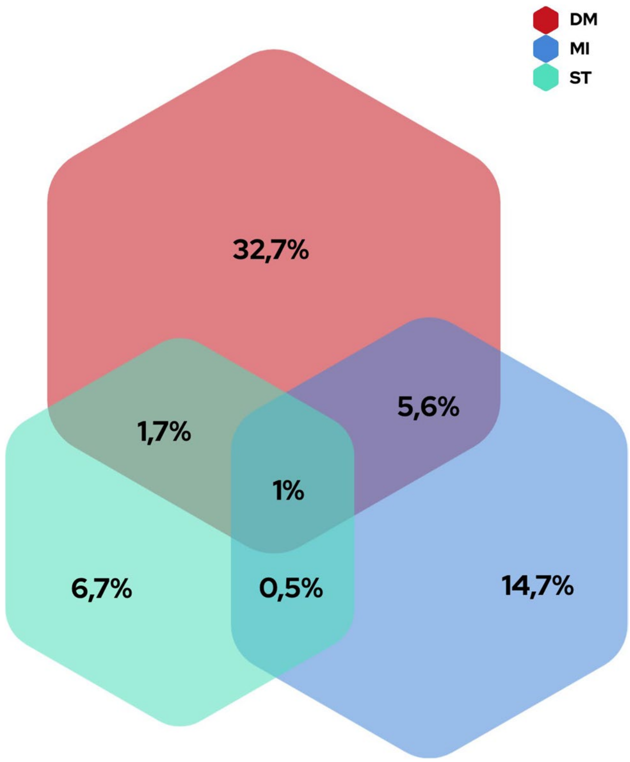

Fig. 1 Venn diagram showing the prevalence and combinations of cardiometabolic diseases in individuals with hypertension from the first BHR. DM: diabetes mellitus; MI: myocardial infarction and, ST: stroke

Table 2 Factors associated with CM-MM among participants in the first BHR

	Crude OR (95%CI)	*p*	Adjusted OR (95%CI)	*p*
Sex				
Female	1		1	
Male	2.32 (1.62–3.89)	< 0.001	2.55 (1.62–4.03)	< 0.001
Age group				
65–69	1		1	
70–74	0.55 (0.32–0.95)	0.034	0.61 (0.34–1.07)	0.086
≥75	0.53 (0.31–0.89)	0.018	0.51 (0.30–0.88)	0.015
Colour				
White	1		-	-
Brown	0.88 (0.52–1.49)	0.641	-	-
Black	0.64 (0.34–1.23)	0.187	-	-
Dyslipidaemia	2.47 (1.55–3.95)	< 0.001	2.55 (1.56–4.16)	< 0.001
Myocardial revascularisation	3.68 (2.16–6.28)	< 0.001	3.11 (1.75–5.42)	< 0.001
Heart failure	2.46 (1.27–4.79)	0.006	2.32 (1.14–4.74)	0.020
Chronic kidney disease	2.01 (0.87–4.65)	0.102	1.81 (0.74–4.42)	0.191
Uncontrolled blood pressure	0.84 (0.54–1.29)	0.441	-	-
Obesity	1.32 (0.85–2.05)	0.211	-	-
Physical activity	0.91 (0.58–1.42)	0.667	-	-
Smoking	1.14 (0.39–3.28)	0.804	-	-
Alcohol use disorder	0.90 (0.31–2.57)	0.852	-	-

(Table 2). In contrast, belonging to the older age group, particularly ≥ 75, was associated with a lower occurrence of CM-MM.

Discussion

This is the first study to analyse the occurrence of CM-MM and its associated factors in patients with hypertension in the Brazilian population. The prevalence of CM-MM was 8.9%, underscoring the need for coordinated assessment and management of coexisting chronic diseases, especially those that affect the cardiometabolic system. These findings highlight the importance of CM-MM in the Brazilian population of older individuals with hypertension and emphasise the need to address CM-MM comprehensively, avoiding fragmented and disease-centred care.

The strongest associations with CM-MM were observed in males with dyslipidaemia, coronary artery bypass grafting, and heart failure. A higher prevalence in males was also identified in studies conducted in Sweden [14], the United States [18], and the United Kingdom [35]. Conversely, studies in China [15], South Africa [16], Mexico [17], and Canada [12] reported a higher prevalence in females.

A lower occurrence of CM-MM was observed in older individuals, which is consistent with the available scientific evidence. Older age is associated with an increased incidence of cardiometabolic diseases, but its incidence tends to decrease slightly among older adults, subsequently stabilising in the population > 70 years [36–38].

There were no statistically significant differences in the occurrence of CM-MM between individuals of different colours. However, in populations with more apparent color categorization, such as the United States, the prevalence of CM-MM is higher in Black than in White individuals [18]. Since most of the studies associating CM-MM with colour included populations with low miscegenation, it is key to understand the effect of the racial diversity of the Brazilian population on the incidence and management of CVD [39].

The scientific literature indicates that hypertension is the clinical condition most frequently associated with other morbidities and the most prevalent within clusters of morbidities, with CM-MM often occurring in individuals with hypertension [23, 40]. In this study, dyslipidaemia, myocardial revascularisation, and heart failure were associated with a higher prevalence of CM-MM, with odds ratios of 2.55, 3.11, and 2.32, respectively. The cluster of cardiometabolic conditions is often the most prevalent and, depending on the age group studied, includes conditions not included in the definition of CM-MM [6]. Therefore, the conditions mentioned above are expected to be significantly associated with CM-MM, especially in older populations and populations in the same age group as the study participants.

In our study, blood pressure management did not differ significantly between individuals with and without CM-MM. A study carried out in six middle-income countries (China, Ghana, India, Mexico, Russia, and South Africa) reported that while individuals with a higher number of morbidities can receive prompter diagnoses of chronic conditions, this does not necessarily lead to better management and control of their conditions [41]. The lack of significant differences in blood pressure control between individuals with and without CM-MM in our study can be attributed to the sample being recruited from specialised hypertension centres, which often recruit patients with more challenging blood pressure management profiles.

Various health conditions can influence blood pressure control, including diabetes, heart failure, ischaemic heart disease, schizophrenia, depression or anxiety, dementia, and osteoarthritis [42, 43]. However, evidence does not suggest that specific multimorbidity clusters are associated with higher blood pressure [44]. Despite a greater number of comorbidities being associated with lower blood pressure, control rates among treated patients are lower in patients with multimorbidities [29, 44–46]. Future research on the subject should include a broader list of morbidities and assess morbidity clustering within the study population.

The practical implications of this study for health care include the importance of family and community physicians and cardiologists adopting an integrated approach to manage cardiovascular morbidities [47–49]. Although most clinical guidelines focus on single conditions, a comprehensive and patient-centred approach is necessary for the clinical routine for optimising clinical outcomes [50, 51].

From a public health point of view, this study highlights the need for expanded, cost-effective, and patient-centred care models. Although not the main focus of our research, it is well established that individuals with clusters of cardiometabolic diseases often experience a decreased health-related quality of life [40]. Therefore, prioritising understanding and decision making about the health care of people with CM-MM is essential from the perspective of public health policies. Future studies should evaluate the outcomes and experiences of individuals with CM-MM, thus improving our understanding of the impact of CM-MM on quality of life. Furthermore, it is crucial to understand the patterns of use of health services and the behaviour of individuals seeking care, particularly in relation to emergency services and hospital admissions.

The availability and use of data from a patient registry not specifically designed to evaluate multimorbidity present some limitations. First, an extensive list of morbidities was not used due to the nature of the BHR, which could have shown additional patterns of morbidity clusters, associations between them, and the effects of CM-MM compared to these clusters. Second, the data were collected from a pre-selected population, specifically individuals with AH. However, this is the first study on CM-MM, and the associations identified here may inform other studies aimed at evaluating the magnitude of CM-MM in different contexts.

Finally, we hope that the data presented in this study will increase awareness among researchers, scientific societies, and decision makers about the importance of including CM-MM in discussions on Brazilian cardiovascular public health. We also hope to contribute to the development and implementation of care models with an integrated and comprehensive approach that places the individual at the centre of care.

Abbreviations

BHR	Brazilian Hypertension Registry
BMI	Body mass index
CM-MM	Cardiometabolic multimorbidity
DBP	Diastolic blood pressure
DM	Diabetes mellitus
LMICs	Low- and middle-income countries
MI	Myocardial infarction
NCDs	Non-communicable diseases
SBP	Systolic blood pressure
ST	Stroke

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12872-025-05144-2.

Supplementary Material 1.

Acknowledgements

We thank the individual who participated in the first BHR and to the Brazilian Society of Cardiology Hypertension Department for awarding the database concerning this nationwide registry.

Authors' contributions

Research designed by AAB, ECDB, ADMF, MVBM, MGM, CA, RMSP, RDL, PCBVJ, ALLS, WKSB (project development, objectives, research methods); SRRB and PVOV conducted data analysis; SRRB, LFM, PVOV and WKSB wrote the article and were mainly responsible for the final content; and all authors assisted in the interpretation of results and critical revision of the manuscript. All authors contributed to the final manuscript and approved the final version.

Funding

The study was supported by the Brazilian National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPQ) (grant 313481/2020-2) for WKSB. The study funders and supporters had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability
The datasets used in this study are available from the corresponding author upon request.

Declarations

Ethics approval and consent to participate
All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. The Research Ethics Committee of the Clinics Hospital of the Federal University of Goiás approved the first BHR under protocol nº 532146. All participants signed an informed consent form before the interviews started. All participants were informed about the objectives of the research and signed separate informed consent forms for the interviews and physical measurements.

Consent for publication
The first BHR participants are volunteers who have provided written informed consent. No personal details were used in this study.

Competing interests
The authors declare no competing interests.

Clinical trial number
Not applicable.

Author details
[1]Faculty of Medicine, Federal University of Goiás, Goiânia, Brazil
[2]Hypertension Unit, Federal University of Goiás, Goiânia, Brazil
[3]School of Social and Health Sciences, Pontifical Catholic University of Goiás, Goiânia, Brazil
[4]Rio de Janeiro State University, Rio de Janeiro, Brazil
[5]Porto Alegre Institute of Cardiology, Porto Alegre, Brazil
[6]Cardiology Emergency Service, University of Pernambuco, Recife, Brazil
[7]Minas Gerais School of Medical Sciences, Lucas Machado Educational Foundation, Belo Horizonte, Brazil
[8]Alagoas State University of Medical Sciences, Maceió, Brazil
[9]Dante Pazzanese Institute of Cardiology, São Paulo, Brazil
[10]Federal University of São Paulo, São Paulo, Brazil
[11]Division of Cardiology, Duke University, Durham, USA
[12]Faculty of Nursing, Federal University of Goiás, Goiânia, Brazil

Received: 31 January 2025 / Accepted: 18 August 2025
Published online: 01 October 2025

References
1. Hacker K. The burden of chronic disease. Mayo Clinic Proceedings: Innovations, Quality & Outcomes. 2024;8(1):112–9. https://doi.org/10.1016/j.mayocpiqo.2023.08.005.
2. WHO. Global Status Report on Noncommunicable Diseases 2014.Geneva: World Health Organization. 2014. Available at: https://apps.who.int/iris/handle/10665/148114
3. The PLOS Medicine Editors. Multimorbidity: addressing the next global pandemic. PLoS Med. 2023;20(4):e1004229. https://doi.org/10.1371/journal.pmed.1004229.
4. Pearson-Stuttard J, Ezzati M, Gregg EW. Multimorbidity—a defining challenge for health systems. Lancet Public Health. 2019;4(12):e599–600. https://doi.org/10.1016/S2468-2667(19)30222-1.
5. Glynn LG. Multimorbidity: another key issue for cardiovascular medicine. Lancet. 2009;374(9699):1421–2. https://doi.org/10.1016/S0140-6736(09)61863-8.
6. Batista SR, Sousa ALL, Nunes BP, Silva RR, Jardim PCBV. Identifying multimorbidity clusters among Brazilian older adults using network analysis: findings and perspectives. PLoS One. 2022;17(7):e0271639. https://doi.org/10.1371/journal.pone.0271639.
7. Beard JR, Officer A, de Carvalho IA, Sadana R, Pot AM, Michel JP, Lloyd-Sherlock P, Epping-Jordan JE, Peeters GMEEG, Mahanani WR, Thiyagarajan JA, Chatterji S. The world report on ageing and health: a policy framework for healthy ageing. Lancet. 2016;387(10033):2145–54. https://doi.org/10.1016/S0140-6736(15)00516-4.
8. Forman DE, Maurer MS, Boyd C, Brindis R, Salive ME, Horne FM, Bell SP, Fulmer T, Reuben DB, Zieman S, Rich MW. Multimorbidity in older adults with cardiovascular disease. J Am Coll Cardiol. 2018;71(19):2149–61. https://doi.org/10.1016/j.jacc.2018.03.022.
9. Emerging Risk Factors Collaboration. Association of cardiometabolic multimorbidity with mortality. JAMA. 2015;314(1):52. https://doi.org/10.1001/jama.2015.7008.
10. Kudesia P, Salimarouny B, Stanley M, Fortin M, Stewart M, Terry A, Ryan BL. The incidence of multimorbidity and patterns in accumulation of chronic conditions: a systematic review. Journal of Multimorbidity and Comorbidity. 2021;11: 26335565211032880. https://doi.org/10.1177/26335565211032880.
11. Garin N, Koyanagi A, Chatterji S, Tyrovolas S, Olaya B, Leonardi M, Lara E, Koskinen S, Tobiasz-Adamczyk B, Ayuso-Mateos JL, Haro JM. Global multimorbidity patterns: a cross-sectional, population-based, multi-country study. J Gerontol A Biol Sci Med Sci. 2016;71(2):205–14. https://doi.org/10.1093/gerona/glv128.
12. Sakakibara BM, Obembe AO, Eng JJ. The prevalence of cardiometabolic multimorbidity and its association with physical activity, diet, and stress in Canada: evidence from a population-based cross-sectional study. BMC Public Health. 2019;19(1):1361. https://doi.org/10.1186/s12889-019-7682-4.
13. Jiang Z, Zhang S, Zeng P, Wang T. Influence of social deprivation on morbidity and all-cause mortality of cardiometabolic multi-morbidity: a cohort analysis of the UK biobank cohort. BMC Public Health. 2023;23(1):2177. https://doi.org/10.1186/s12889-023-17008-5.
14. Dove A, Guo J, Marseglia A, Fastbom J, Vetrano DL, Fratiglioni L, Pedersen NL, Xu W. Cardiometabolic multimorbidity and incident dementia: the Swedish twin registry. Eur Heart J. 2023;44(7):573–82. https://doi.org/10.1093/eurheartj/ehac744.
15. Zhang D, Tang X, Shen P, Si Y, Liu X, Xu Z, Wu J, Zhang J, Lu P, Lin H, Gao P. Multimorbidity of cardiometabolic diseases: prevalence and risk for mortality from one million Chinese adults in a longitudinal cohort study. BMJ Open. 2019;9(3):e024476. https://doi.org/10.1136/bmjopen-2018-024476.
16. Sewpaul R, Mbewu AD, Fagbamigbe AF, Kandala NB, Reddy SP. Prevalence of multimorbidity of cardiometabolic conditions and associated risk factors in a population-based sample of South Africans: a cross-sectional study. Public Health Pract. 2021;2: 100193. https://doi.org/10.1016/j.puhip.2021.100193.
17. Agudelo-Botero M, Dávila-Cervantes CA, Giraldo-Rodríguez L. Cardiometabolic multimorbidity in Mexican adults: a cross-sectional analysis of a national survey. Front Med. 2024;11: 1380715. https://doi.org/10.3389/fmed.2024.1380715.
18. Cheng X, Ma T, Ouyang F, Zhang G, Bai Y. Trends in the prevalence of cardiometabolic multimorbidity in the United States, 1999–2018. Int J Environ Res Public Health. 2022;19(8): 4726. https://doi.org/10.3390/ijerph19084726.
19. Powell-Wiley TM, Baumer Y, Baah FO, Baez AS, Farmer N, Mahlobo CT, Pita MA, Potharaju KA, Tamura K, Wallen GR. Social determinants of cardiovascular disease. Circ Res. 2022;130(5):782–99. https://doi.org/10.1161/CIRCRESAHA.121.319811.
20. Li D, Wang L, Zhou Z, Song L, Chen S, Yang Y, Hu Y, Wang Y, Wu S, Tian Y. Role of socioeconomic, lifestyle, and clinical factors in the progression of cardiometabolic multimorbidity in China: a 10-year prospective cohort study. Nutr Metab Cardiovasc Dis. 2022;32(10):2383–91. https://doi.org/10.1016/j.numecd.2022.06.016.
21. Jiang M, Tian S, Liu S, Wang Y, Guo X, Huang T, Lin X, Belsky DW, Baccarelli AA, Gao X. Accelerated biological aging elevates the risk of cardiometabolic multimorbidity and mortality. Nat Cardiovasc Res. 2024;3(3):332–42. https://doi.org/10.1038/s44161-024-00438-8.
22. Otieno P, Asiki G, Wekesah F, Wilunda C, Sanya RE, Wami W, Agyemang C. Multimorbidity of cardiometabolic diseases: a cross-sectional study of patterns, clusters and associated risk factors in sub-Saharan Africa. BMJ Open. 2023;13(2):e064275. https://doi.org/10.1136/bmjopen-2022-064275.
23. Janssen-Telders C, Schlaich M, Schutte AE, Stergiou G, Poulter NR, Beaney T. Risk factors for cardiometabolic multimorbidity: an analysis of 4 million participants from May measurement month 2017–2019. Eur Heart J. 2024;45(Supplement1):ehae6662553. https://doi.org/10.1093/eurheartj/ehae666.2553.
24. Joseph JJ, Rajwani A, Roper D, Zhao S, Kline D, Odei J, Brock G, Echouffo-Tcheugui JB, Kalyani RR, Bertoni AG, Effoe VS, Sims M, Wu WC, Wand GS, Golden SH. Associations of cardiometabolic multimorbidity with all-cause and coronary heart disease mortality among black adults in the Jackson heart study. JAMA Netw Open. 2022;5(10):e2238361. https://doi.org/10.1001/jamanetworkopen.2022.38361.

25. Canoy D, Tran J, Zottoli M, Ramakrishnan R, Hassaine A, Rao S, Li Y, Salimi-Khorshidi G, Norton R, Rahimi K. Association between cardiometabolic disease multimorbidity and all-cause mortality in 2 million women and men registered in UK general practices. BMC Med. 2021;19(1):258. https://doi.org/10.1186/s12916-021-02126-x.
26. Guo D, Wang Y, Zhao Y, Ding R, Luo Y, Dai W, He P. The longitudinal association between multiple cardiometabolic diseases, socioeconomic status, and depressive symptoms in China. Sci Rep. 2025;15(1):2971. https://doi.org/10.1038/s41598-025-87516-4.
27. Yang W, Li W, Wang S, Qi X, Sun Z, Dove A, Xu W. Association of cardiometabolic multimorbidity with risk of late-life depression: a nationwide twin study. Eur Psychiatry. 2024;67(1): e58. https://doi.org/10.1192/j.eurpsy.2024.1775.
28. Zhao X, Xu X, Yan Y, Lipnicki DM, Pang T, Crawford JD, Chen C, Cheng CY, Venketasubramanian N, Chong E, Blay SL, Lima-Costa MF, Castro-Costa E, Lipton RB, Katz MJ, Ritchie K, Scarmeas N, Yannakoulia M, Kosmidis MH, Gureje O, Ojagbemi A, Bello T, Hendrie HC, Gao S, Guerra RO, Auais M, Gomez JF, Rolandi E, Davin A, Rossi M, Riedel-Heller SG, Löbner M, Roehr S, Ganguli M, Jacobsen EP, Chang CH, Aiello AE, Ho R, Sanchez-Juan P, Valentí-Soler M, Ser TD, Lobo A, De-la-Cámara C, Lobo E, Sachdev PS, Xu X, for Cohort Studies of Memory in an International Consortium (COSMIC). Independent and joint associations of cardiometabolic Multimorbidity and depression on cognitive function: findings from multi-regional cohorts and generalisation from community to clinic. Lancet Reg Health - West Pac. 2024;51:101198. https://doi.org/10.1016/j.lanwpc.2024.101198.
29. Jin Y, Liang J, Hong C, Liang R, Luo Y. Cardiometabolic multimorbidity, lifestyle behaviours, and cognitive function: a multicohort study. Lancet Healthy Longev. 2023;4(6):e265–73. https://doi.org/10.1016/S2666-7568(23)00054-5.
30. Tai XY, Veldsman M, Lyall DM, Littlejohns TJ, Langa KM, Husain M, Ranson J, Llewellyn DJ. Cardiometabolic multimorbidity, genetic risk, and dementia: a prospective cohort study. Lancet Healthy Longev. 2022;3(6):e428–36. https://doi.org/10.1016/S2666-7568(22)00117-9.
31. Dove A, Marseglia A, Shang Y, Grande G, Vetrano DL, Laukka EJ, Fratiglioni L, Xu W. Cardiometabolic multimorbidity accelerates cognitive decline and dementia progression. Alzheimers Dement. 2023;19(3):821–30. https://doi.org/10.1002/alz.12708.
32. Jardim PCBV, Barroso WKS, Lopes RD, Brandão AA, Malachias MV, Gomes MM, Moreno Júnior H, Barbosa EC, Póvoa RM. I RBH - First Brazilian Hypertension Registry. *Arq Bras Cardiol*. Published online 2016. https://doi.org/10.5935/abc.20160120
33. Lopes RD, Barroso WKS, Brandao AA, Barbosa ECD, Malachias MVB, Gomes MM, Amodeo C, Dos Santos Povoa RM, Cavalcante MA, Précoma DB, Sousa ACS, Dantas JMM, Cesarino EJ, Veiga Jardim PCB, RBH investigators. The first Brazilian registry of hypertension. Am Heart J. 2018;205:154–7. https://doi.org/10.1016/j.ahj.2018.08.012.
34. Sociedade Brasileira de Cardiologia. Sociedade Brasileira de hipertensão, sociedade Brasileira de nefrologia. [VI Brazilian guidelines on hypertension]. Arq Bras Cardiol. 2010;95(1 Suppl):1–51.
35. Lu Y, Li G, Ferrari P, Freisling H, Qiao Y, Wu L, Shao L, Ke C. Associations of handgrip strength with morbidity and all-cause mortality of cardiometabolic multimorbidity. BMC Med. 2022;20(1):191. https://doi.org/10.1186/s12916-022-02389-y.
36. Yao SS, Cao GY, Han L, Chen ZS, Huang ZT, Gong P, Hu Y, Xu B. Prevalence and patterns of multimorbidity in a nationally representative sample of older Chinese: results from the China health and retirement longitudinal study. J Gerontol Ser A. 2020;75(10):1974–80. https://doi.org/10.1093/gerona/glz185.
37. Abebe F, Schneider M, Asrat B, Ambaw F. Multimorbidity of chronic non-communicable diseases in low- and middle-income countries: a scoping review. J Comorbidity. 2020;10: 2235042X2096191. https://doi.org/10.1177/2235042X20961919.
38. Lyall DM, Celis-Morales CA, Anderson J, Gill JM, Mackay DF, McIntosh AM, Smith DJ, Deary IJ, Sattar N, Pell JP. Associations between single and multiple cardiometabolic diseases and cognitive abilities in 474 129 UK biobank participants. Eur Heart J Published Online November. 2016;15:ehw528. https://doi.org/10.1093/eurheartj/ehw528.
39. Barroso WKS, Batista SR, Vitorino PVDO, Sousa ALL. Influence of Racial composition on blood pressure control in the Brazilian population: the need for new perspectives beyond drug treatment. Arq Bras Cardiol. 2022;118(3):623–4. https://doi.org/10.36660/abc.20220063.
40. Steell L, Krauth SJ, Ahmed S, Dibben GO, McIntosh E, Hanlon P, Lewsey J, Nicholl BI, McAllister DA, Smith SM, Evans R, Ahmed Z, Dean S, Greaves C, Barber S, Doherty P, Gardiner N, Ibbotson T, Jolly K, Ormandy P, Simpson SA, Taylor RS, Singh SJ, Mair FS, Jani BD. PERFORM research team. Multimorbidity clusters and their associations with health-related quality of life in two UK cohorts. BMC Med. 2025;23(1):1. https://doi.org/10.1186/s12916-024-03811-3.
41. Sum G, Koh GC, Mercer SW, Wei LY, Majeed A, Oldenburg B, Lee JT. Patients with more comorbidities have better detection of chronic conditions, but poorer management and control: findings from six middle-income countries. BMC Public Health. 2020;20(1): 9. https://doi.org/10.1186/s12889-019-8112-3.
42. Nguyen TN, Kalia S, Hanlon P, Jani BD, Nicholl BI, Christie CD, Aliarzadeh B, Moineddin R, Harrison C, Chow C, Fortin M, Mair FS, Greiver M. Multimorbidity and blood pressure control in patients attending primary care in Canada. J Prim Care Community Health. 2023;14:21501319231215025. https://doi.org/10.1177/21501319231215025.
43. Araújo TDP, Borges LGS, Barroso WKS, Brandão AA, Barbosa ECD, Feitosa ADM, Malachias MVB, Mota Gomes M, Amodeo C, Povoa RMDS, Jardim PCBV, Lopes RD, Batista SRR, Vitorino PVO. Researchers of study I rbh.factors associated with uncontrolled blood pressure in hypertensive Brazilians. J Clin Hypertens. 2022;24(7):814–24. https://doi.org/10.1111/jch.14501.
44. Tran J, Norton R, Canoy D, Ayala Solares JR, Conrad N, Nazarzadeh M, Raimondi F, Salimi-Khorshidi G, Rodgers A, Rahimi K. Multi-morbidity and blood pressure trajectories in hypertensive patients: a multiple landmark cohort study. PLoS Med. 2021;18(6):e1003674. https://doi.org/10.1371/journal.pmed.1003674.
45. Yang L, Luo Y, He L, Yin J, Li T, Liu S, Li D, Cheng X, Bai Y. Shift work and the risk of cardiometabolic multimorbidity among patients with hypertension: a prospective cohort study of UK biobank. J Am Heart Assoc. 2022;11(17): e025936. https://doi.org/10.1161/JAHA.122.025936.
46. Batista SR, Stein AT, Vitorino PVDO, Flores TR, Sousa ALL, Nunes BP. A10768 effect of Multimorbidity on blood pressure control among Brazilian adults: data from the 2013 National health survey. J Hypertens. 2018;36:e285–6. https://doi.org/10.1097/01.hjh.0000549166.20829.9b.
47. Wójcik C, Shapiro MD. Bridging the gap between cardiology and family medicine: missed opportunities in cardiovascular disease prevention. Circulation. 2019;140(9):709–11. https://doi.org/10.1161/CIRCULATIONAHA.119.040151.
48. Penm J, MacKinnon NJ, Strakowski SM, Ying J, Doty MM. Minding the gap: factors associated with primary care coordination of adults in 11 countries. Ann Fam Med. 2017;15(2):113–9. https://doi.org/10.1370/afm.2028.
49. Falces C, Andrea R, Heras M, Vehí C, Sorribes M, Sanchis L, Cevallos J, Menacho I, Porcar S, Font D, Sabaté M, Brugada J. Integration between cardiology and primary care: impact on clinical practice. Rev Esp Cardiol. 2011;64(7):564–71. https://doi.org/10.1016/j.recesp.2011.02.021.
50. Hwang K, Moore KJ, Chong TWH, Williams S, Batchelor F. Improving clinical practice guidelines for older people: considerations and recommendations for more inclusive and ageing-relevant guidelines. Lancet Healthy Longev. 2022;3(5):e316–7. https://doi.org/10.1016/S2666-7568(22)00074-5.
51. Hughes LD, McMurdo MET, Guthrie B. Guidelines for people not for diseases: the challenges of applying UK clinical guidelines to people with multimorbidity. Age Ageing. 2013;42(1):62–9. https://doi.org/10.1093/ageing/afs100.

Publisher's Note