Supplemental Online Content

Yu EYT, Wan EYF, Mak IL, et al. Assessment of hypertension complications and health service use 5 years after implementation of a multicomponent intervention. *JAMA Netw Open*. 2023;6(5):e2315064. doi:10.1001/jamanetworkopen.2023.15064

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This supplemental material has been provided by the authors to give readers additional information about their work.

eMethods 1. Setting of RAMP-HT and Usual Care

Risk Assessment and Management Program for Hypertension (RAMP-HT)

The RAMP-HT introduced three specific services to augment the time-constrained usual care: risk assessment, nurse intervention and specialist consultation.

All participants would undergo a comprehensive, protocol-guided risk assessment conducted by a trained nurse, which involves standardized cardiovascular disease (CVD) risk assessment (including smoking habit, blood pressure (BP) level, lipid profile, glycaemic status and obesity), hypertensive complication screening (including the presence of left ventricular hypertrophy, arrhythmia and/or ischaemic heart disease by electrocardiogram, cerebrovascular disease from medical history, peripheral vascular disease by vascular doppler assessment, chronic kidney disease and proteinuria by laboratory testing), and detailed assessment on self-care (including medication adherence, smoking, diet and exercise habits, and self-BP monitoring practice). Each participant would then be stratified as having low, medium or high risk according to the 10-year predicted CVD risk calculated using the Joint British Societies' (JBS2) risk calculator. Based on individual risk level, presence of other CVD risk factors and participants' preference, the nurse – serving as care-manager, would empower the participants on self-care (e.g. lifestyle and self-BP monitoring), prepare a care plan and coordinate follow-up interventions by a multi-disciplinary team for the participants according to protocol. To enhance communication and facilitate clinical decision-making of team members, the care-manager record would record each participant's CVD risk profile and care plan on an electronic record platform with an action reminder system, which is accessible to all doctors and nurses from the Hospital Authority clinical management system across all 73 General Out-Patient Clinics (GOPC). The risk assessment might be repeated every 12-30 months depending on the participant's risk profile.

Participants with adherence issues or specific risk factors would be referred for nurse interventions; participants with resistant hypertension (i.e. SBP \geq 160/100 mm Hg despite taking at least 3 antihypertensive medications) would be referred for additional specialist consultations. High risk participants who were found to have suboptimal blood pressure, lipid or glycaemic control, abnormal findings from investigations, problems with drug compliance, and new symptoms suggestive of hypertension-related complications or adverse effects from treatment would be channelled to an early GOPC follow-up. Meanwhile, all participants would continue to receive care from their usual primary care doctors every 8-16 weeks at GOPCs, who would receive an electronic report on the participants' CVD risk control and additional intervention received, and an action reminder to facilitate medication titration. The usual care doctors might also provide care for other co-morbidities and new health problems during the scheduled follow-ups.

Two cycles of evaluation on the quality of care of the RAMP-HT were conducted in 2013 and 2015, which confirmed satisfactory adherence to the RAMP-HT protocol.²

To implement the RAMP-HT as an add-on intervention to usual care, RAMP-HT services were gradually set up at 59 out of 73 GOPCs in Hong Kong between October 2011 to September 2013 to serve patients residing in different geographic clusters. All patients aged 18 years or above who had hypertension and were receiving management in any of the 73 GOPCs, but no pre-existing diabetes mellitus (DM), CVD or ESRD were eligible to participate in the RAMP-HT, while

patients with concomitant DM were channeled for enrollment in the parallel Risk Assessment and Management Program for Diabetes Mellitus (RAMP-DM) instead.³ Patients were recruited by their attending usual care doctors or nurses to voluntarily enroll in the RAMP-HT during their scheduled follow-up visits. Patients under care of a GOPC without RAMP-HT service would be invited to enroll in RAMP-HT services at a nearest RAMP-HT clinic within the same geographic district, while continue to receive usual follow-up care at their home clinic with the support of the electronic action reminder system.

Although the RAMP-HT is a territory-wide program intended for all patients with hypertension managed in GOPCs, roll-out of the program could only be performed in stages due to the large and ever-increasing number of patients, limited resources and manpower. Therefore, this represented an opportunity to examine the outcomes of RAMP-HT compared to usual care prior to its complete implementation in the public primary care setting.

Usual care

Patients with hypertension are offered a scheduled follow-up consultation with a doctor at a GOPC every 8 to 16 weeks. All GOPC doctors have been trained to deliver standardized hypertension care according to the Hong Kong reference framework for hypertension in primary care. During a typical 5-minutes consultation, the attending doctor may review the patient's BP and control of other risk factors, titrate medication, advise on lifestyle, arrange assessment or refer to allied health professionals as appropriate. Based on clinical judgement, the doctor may also focus on managing the patient's other health problems not directly related to hypertension care during the follow-up appointment. The patients are not required to register with a specific clinic or a regular doctor.

Availability of medications (including statin and angiotensin receptor blockers introduced to the GOPC formulary in 2010), access to all laboratory tests, investigations and allied health professional services in the public primary care clinics and community centers are the same for RAMP-HT participants and usual care patients.

References

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- 2. Yu EY, Wan EY, Chan KH, et al. Evaluation of the quality of care of a multi-disciplinary Risk Factor Assessment and Management Programme for Hypertension (RAMP-HT). *BMC Fam Pract*. Jun 19 2015;16(1):71. doi:10.1186/s12875-015-0291-0
- 3. Fung CS, Chin WY, Dai DS, et al. Evaluation of the quality of care of a multi-disciplinary risk factor assessment and management programme (RAMP) for diabetic patients. *BMC family practice*. 2012;13(1):1-9.
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eMethods 2. Baseline Covariates

Baseline covariates included socio-demographics, medical history, and anthropometric measurements and laboratory investigation results that were routinely collected at GOPC follow-up and extracted from the electronic health records from the Hospital Authority Clinical Management System.

Socio-demographics included gender, age and smoking status.

Medical history included the Charlson Comorbidity Index, prescriptions of anti-hypertensive medications including angiotensin converting enzyme inhibitor/angiotensin receptor blocker (ACEI/ARB), β-blocker, calcium channel blocker (CCB), diuretic or other anti-hypertensive medications, and lipid-lowering agents.

Anthropometric measurements included body weight, height, and SBP and diastolic BP (DBP) measured using semi-automated blood pressure measurement devices.

Laboratory results consisted of a full lipid profile (low-density lipoprotein-cholesterol (LDL-C), total cholesterol, high-density lipoprotein-cholesterol (HDL-C) and triglycerides), fasting glucose (FG) levels, and estimated glomerular filtration rate (eGFR) calculated with the abbreviated Modification of Diet in Renal Disease Study formula recalibrated for Chinese. All laboratory assays were performed in laboratories accredited by the College of American Pathologists, the Hong Kong Accreditation Service or the National Association of Testing Authorities, Australia.

References

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eFigure 1. Risk Assessment & Management Program - Hypertension (RAMP-HT) workflow

Risk Assessment by	care-manager nurse
Drug Adherence and Lifestyle	 Adherence to medication by pill-counting and prescription review Smoking habit, alcohol consumption Diet, exercise Self BP-monitoring
Physical Examination	 Blood pressure and pulse Body weight, body height, BMI and waist circumference Foot pulse (by vascular Doppler)
Laboratory Tests	 Blood tests for full lipid profile, fasting glucose level, and renal function Urine for protein Electrocardiogram



Risk Stratification based on 10-years' Cardiovascular Disease Risk Calculation using the Joint British Societies (JBS2) risk calculator

Low Risk	Medium Risk	High Risk
(<10%)	(10-20%)	(>20% or with TOD)



Patient Education

- Explanation of risk level
- HT knowledge, self-care practices, Lifestyle advices
- Coordination of multi-disciplinary risk-guided management



Risk-guided Multi-disciplinary Interventions												
Blood pressure	Low Risk (<10%)	Medium Risk (10-20%)	High Risk (>20% or with TOD)									
140/90 – 160/100 mm Hg	GOPC Doctor for drug titration	GOPC Doctor for drug titration	GOPC Doctor for drug titration + add statins if LDL-C suboptimal									
≥ 160/100 mm Hg	GOPC Doctor for drug ti	tration + <u>RAMP-HT Nur</u>	rse Intervention									
≥ 160/100 mm Hg + On ≥ 3 kinds of anti-HT drugs	00 mm Hg + Specialist Consultation for further assessment and management											

Other Risk-guided Interventions:

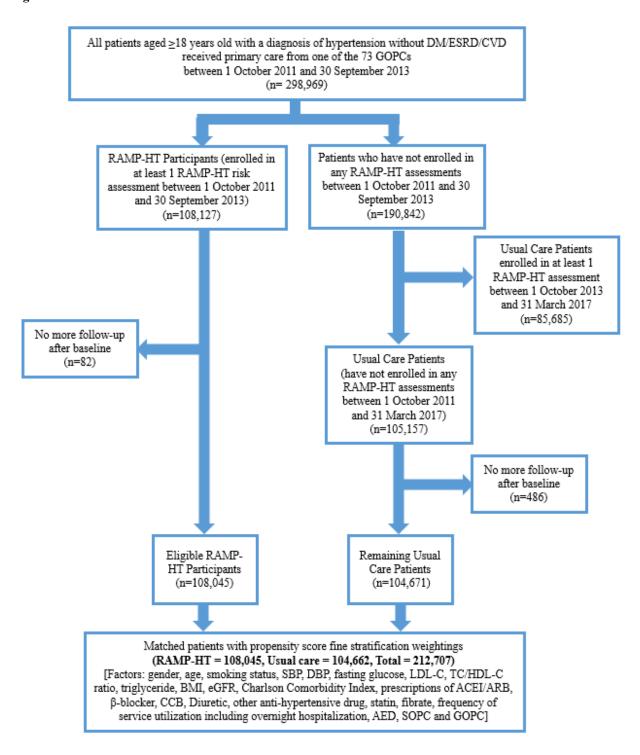
Patient Empowerment Program – offer to all HT patients who are willing to attend **Smoking Counselling and Cessation Program/Centre** – smokers intending to quit

Dietitian – (1) BMI \geq 27.5kg/m² for weight reduction and (2) special dietary needs and (3) poor dietary control despites nurse intervention offered and (4) pre-diabetes

Physiotherapist – BMI ≥ 27.5kg/m² intending to join weight reduction program

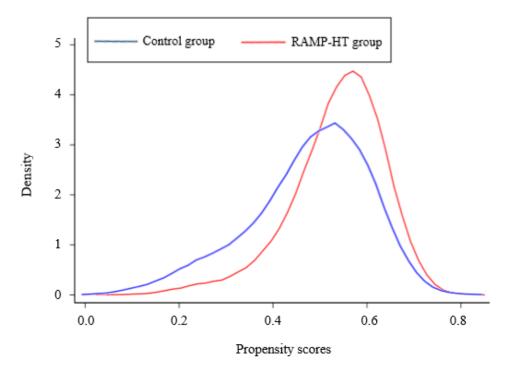
Integrated Mental Health Program by occupational therapist – psychological problems

eFigure 2. Patient inclusion flow chart



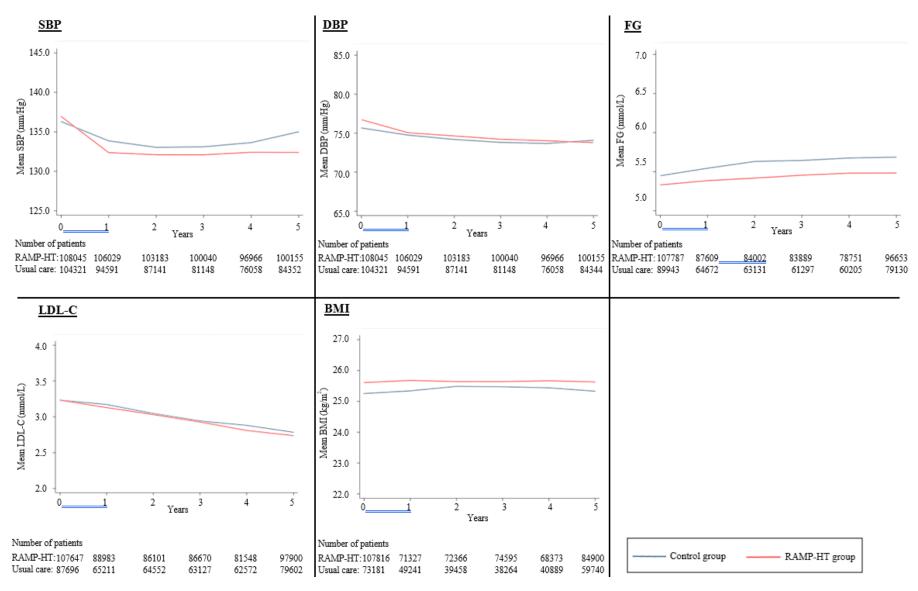
(Abbreviations: ACEI = angiotensin-converting enzyme inhibitors; ARB = angiotensin receptor blockers; AED = accident and emergency department; BMI = body mass index; CCB = calcium channel blockers; CVD = cardiovascular disease; DBP = diastolic blood pressure; DM=Diabetes Mellitus; eGFR = estimated glomerular filtration rate; ESRD = end-stage renal disease; GOPC = general out-patient clinic; HDL-C = high-density lipoprotein-cholesterol; LDL-C = low-density lipoprotein-cholesterol; RAMP-HT = Risk Assessment and Management Program – Hypertension; SBP = systolic blood pressure; SOPC = specialist out-patient clinic; TC = total cholesterol)

eFigure 3. Propensity scores distributions of RAMP-HT group and usual care group



RAMP-HT = Risk Assessment and Management Program – Hypertension

eFigure 4. Means of Systolic Blood Pressure, Diastolic Blood Pressure, Fasting Glucose, Low Density Lipoprotein – Cholesterol and Body Mass Index of RAMP-HT group and usual care group



RAMP-HT = Risk Assessment and Management Program - Hypertension; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; FG = Fasting Glucose; LDL-C = Low Density Lipoprotein - Cholesterol; BMI = Body Mass Index

eFigure 5. Adjusted hazard ratios (HRs) of RAMP-HT participants over usual care patients associated with the incidences of cardiovascular diseases (CVD), end-stage renal disease (ESRD), all-cause mortality and all composite event in selected subgroups by multivariable Cox proportional hazards regressions. HR were adjusted for all covariates at baseline.

Overall	All composite	event 580(0.567,0.593)	r C'	VD + 0.624(0.607,0.641)	esr	D 0.543(0.498,0.593)	All-cat ■	use mortality 0.519(0.502,0.537)
Female		594(0.575,0.614)	•	0.645(0.621,0.670)	-	0.557(0.490,0.633)	•	0.523(0.496,0.552)
Male	9	574(0.557,0.592)		0.614(0.591,0.638)	-	0.526(0.469,0.591)		0.523(0.500,0.548)
Age < 65 years old	1	561(0.535,0.588)	-	0.608(0.576,0.641)	-	0.504(0.402,0.630)	-	0.432(0.394,0.474)
Age $\geq 65 \& < 80$ years old	1	560(0.542,0.578)		0.605(0.582,0.629)	-	0.479(0.421,0.544)		0.483(0.459,0.508)
Age \geq 80 years old	i i	664(0.635,0.694)	-	0.700(0.661,0.741)		0.680(0.591,0.781)	-	0.625(0.589,0.662)
Non or Ex-smoker	o .	590(0.576,0.604)	•	0.632(0.615,0.650)	+	0.540(0.494,0.592)	•	0.530(0.511,0.550)
Smoker	• 0.	562(0.521,0.606)	-	0.586(0.532,0.645)	-	0.570(0.432,0.753)	-	0.517(0.464,0.576)
SBP < 140mmHg	a 0.	586(0.569,0.604)	•	0.641(0.619,0.665)	-	0.483(0.426,0.547)		0.516(0.493,0.540)
SBP ≥ 140 & < 160mmHg	0.	579(0.557,0.601)	•	0.615(0.587,0.644)	-	0.562(0.489,0.645)		0.520(0.490,0.553)
SBP≥160mmHg	• 0.	580(0.537,0.626)	-	0.600(0.547,0.659)		0.822(0.641,1.054)	-	0.557(0.495,0.628)
Fasting glucose < 6.1 mmol/L	0.	568(0.554,0.581)	•	0.614(0.597,0.632)	•	0.538(0.492,0.588)		0.507(0.489,0.526)
Fasting glucose ≥ 6.1 mmol/L	- 0.	701(0.654,0.751)	-	0.713(0.656,0.775)		0.551(0.419,0.725)	-	0.653(0.588,0.725)
Controlled LDL-C†	• 0.	572(0.552,0.593)		0.622(0.596,0.649)	+	0.542(0.467,0.630)		0.510(0.483,0.539)
Uncontrolled LDL-C†	• 0.	584(0.568,0.601)	•	0.623(0.601,0.644)	+	0.534(0.480,0.595)		0.523(0.500,0.547)
$eGFR \ge 60ml/min/1.73m^2$	• 0.	572(0.559,0.585)	•	0.613(0.596,0.630)	-	0.528(0.471,0.592)		0.501(0.483,0.519)
$eGFR < 60ml/min/1.73m^2$	• 0.	604(0.560,0.652)	-	0.678(0.613,0.750)	+	0.557(0.484,0.640)	-	0.621(0.562,0.687)
$BMI \le 23kg/m^2$	0.	592(0.566,0.619)	-	0.657(0.618,0.699)		0.695(0.569,0.848)		0.534(0.504,0.566)
$BMI \ge 23 \& \le 25 kg/m^2$	0.	556(0.529,0.583)	=	0.606(0.571,0.643)		0.454(0.370,0.556)	=	0.473(0.438,0.511)
$BMI \ge 25 \& < 30 kg/m^2$	• 0.	589(0.568,0.610)		0.618(0.593,0.645)	-	0.493(0.430,0.565)	-	0.524(0.493,0.557)
$\mathrm{BMI} \geq 30 kg/m^2$	• 0.	582(0.540,0.626)	-	0.585(0.539,0.636)	+=-	0.635(0.490,0.825)	-	0.544(0.475,0.624)
CVD risk < 10%	a 0.	550(0.510,0.592)	+	0.626(0.573,0.684)		0.543(0.394,0.748)	-	0.405(0.354,0.464)
CVD risk $\geq 10\% \& \leq 20\%$	• 0.	577(0.554,0.600)	•	0.623(0.594,0.654)		0.484(0.401,0.584)	-	0.500(0.467,0.536)
CVD risk > 20%	• 0.	589(0.572,0.606)		0.623(0.601,0.646)	+	0.559(0.505,0.619)		0.545(0.522,0.569)
Charlson's Index < 3	0.	564(0.542,0.586)		0.604(0.578,0.632)	-	0.474(0.394,0.571)	-	0.431(0.399,0.465)
Charlson's Index ≥ 3	• 0.	602(0.586,0.619)	•	0.647(0.624,0.670)	-	0.586(0.528,0.650)	=	0.550(0.529,0.573)
No HT drug used	 0.	571(0.458,0.712)	-	0.641(0.496,0.829)		0.908(0.333,2.476)	-	0.475(0.330,0.685)
1 HT drug used	o .	577(0.559,0.596)	•	0.630(0.606,0.655)	-	0.500(0.433,0.577)		0.510(0.486,0.536)
2 HT drugs used	0.	576(0.556,0.597)		0.610(0.584,0.637)	+	0.528(0.464,0.601)		0.522(0.494,0.551)
3 or more HT drugs used	.	628(0.586,0.673)	-	0.673(0.619,0.730)	+=-	0.620(0.505,0.761)	-	0.570(0.511,0.634)
Use of ACEI/ARB		586(0.558,0.615)	•	0.618(0.583,0.656)		0.587(0.500,0.689)	-	0.566(0.526,0.610)
Use of β-blocker	0.	581(0.560,0.602)		0.620(0.594,0.647)	+	0.546(0.480,0.622)	-	0.513(0.484,0.544)
Use of CCB	• 0.	571(0.557,0.586)		0.611(0.592,0.630)	+	0.532(0.484,0.585)		0.512(0.493,0.533)
Use of Diuretic	• 0.	613(0.575,0.654)	=	0.681(0.631,0.735)		0.515(0.391,0.678)	-	0.530(0.477,0.588)
No statin used	0.	580(0.567,0.594)	•	0.627(0.609,0.645)	+	0.541(0.495,0.592)	•	0.517(0.499,0.536)
Use of statin	• 0.	597(0.554,0.643)	+	0.614(0.563,0.669)	-	0.503(0.378,0.670)	-	0.584(0.510,0.669)
0 0.2 0.4	0.6 0.8 1	0	0.2 0.4 0.6 0.8	1 0	0.2 0.4 0.6 0.8 1		0.2 0.4 0.6 0.8	Adjusted HR

RAMP-HT = Risk Assessment and Management Program – Hypertension; SBP = Systolic Blood Pressure; LDL-C = Low Density Lipoprotein – Cholesterol; eGFR = estimated Glomerular Filtration Rate; BMI = Body Mass Index; CVD risk = Framingham 10-year CVD risk; HT = Hypertension; ACEI = Angiotensin Converting Enzyme Inhibitor; ARB = Angiotensin Receptor Blocker; CCB = Calcium Channel Blocker; †Controlled LDL-C is defined as LDL-C < 3.4 mmol/L for CVD risk \leq 20%, or LDL-C \leq 2.6 mmol/L for CVD risk \geq 20%.

eFigure 6. Adjusted incident rate ratios (IRRs) of RAMP-HT participants over usual care patients associated with the number of hospitalization, accident and emergency department (AED) attendance, special outpatient clinic (SOPC) and general outpatient clinic (GOPC) attendance in selected subgroups by negative binomial regressions. IRRs were adjusted for all covariates at baseline and the corresponding frequency of episode event within one year before baseline.

Overall	Overnight Hospitalization 0.601(0.590,0.613)	A&E attendance 0.696(0.687,0.706)	SOPC attendance 0.871(0.862,0.881)	GOPC attendance 1.061(1.057,1.064)
Female	0.613(0.598,0.629)	0.721(0.708,0.734)	0.877(0.864,0.890)	1.052(1.047,1.057)
Male	0.595(0.578,0.613)	0.669(0.654,0.684)	0.861(0.846,0.877)	1.073(1.067,1.079)
Age < 65 years old	0.663(0.640,0.687)	0.800(0.782,0.818)	0.817(0.802,0.833)	1.038(1.033,1.044)
Age $\geq 65 \& \leq 80$ years old	0.595(0.578,0.613)	0.687(0.672,0.702)	0.851(0.837,0.866)	1.061(1.055,1.067)
Age ≥ 80 years old	0.648(0.625,0.672)	0.709(0.688,0.730)	0.987(0.962,1.013)	1.091(1.080,1.102)
Non or Ex-smoker	0.606(0.594,0.618)	0.702(0.692,0.712)	0.877(0.867,0.888)	1.055(1.051,1.059)
Smoker	0.619(0.575,0.665)	0.690(0.651,0.732)	0.825(0.787,0.864)	1.076(1.059,1.094)
SBP < 140mmHg	0.615(0.600,0.631)	0.703(0.691,0.716)	0.888(0.875,0.902)	1.070(1.065,1.075)
SBP ≥ 140 & < 160mmHg	0.593(0.573,0.614)	0.696(0.679,0.714)	0.862(0.844,0.879)	1.057(1.050,1.064)
SBP≥160mmHg	0.582(0.546,0.620)	0.682(0.649,0.717)	0.844(0.809,0.880)	1.052(1.037,1.068)
Fasting glucose < 6.1 mmol/	L 0 .594(0.582,0.606)	0.691(0.681,0.701)	0.867(0.857,0.878)	1.064(1.060,1.068)
Fasting glucose ≥ 6.1 mmol/	the superior of the superior o	a 0.750(0.716,0.786)	0.892(0.861,0.924)	1 .032(1.022,1.042)
Controlled LDL-C†	0.600(0.582,0.619)	0.695(0.681,0.710)	0.878(0.863,0.893)	1.071(1.065,1.076)
Uncontrolled LDL-C†	0.602(0.587,0.617)	0.698(0.685,0.711)	0.866(0.853,0.879)	1.053(1.048,1.058)
$eGFR \ge 60ml/min/1.73m^2$	0.594(0.582,0.606)	0.692(0.682,0.702)	0.856(0.846,0.866)	1.054(1.050,1.058)
$eGFR < 60ml/min/1.73m^2$	0.624(0.579,0.674)	• 0.693(0.650,0.739)	0.918(0.875,0.964)	1.151(1.127,1.175)
$BMI \le 23kg/m^2$	0.578(0.557,0.600)	0.667(0.649,0.686)	0.883(0.864,0.903)	1.070(1.062,1.078)
$BMI \ge 23 \& \le 25 kg/m^2$	0.565(0.541,0.590)	0.682(0.661,0.703)	0.851(0.830,0.872)	1.070(1.062,1.079)
$BMI \ge 25 \& \le 30 kg/m^2$	0.625(0.607,0.645)	0.720(0.705,0.736)	0.864(0.849,0.880)	1.050(1.044,1.056)
$\mathrm{BMI} \geq 30 kg/m^2$	- 0.669(0.631,0.710)	a 0.760(0.728,0.794)	0.869(0.838,0.901)	1.055(1.043,1.067)
CVD risk < 10%	0.658(0.623,0.694)	0.786(0.761,0.812)	0.846(0.823,0.869)	1.051(1.043,1.059)
CVD risk $\geq 10\% \& \leq 20\%$	0.615(0.594,0.637)	0.722(0.705,0.739)	0.868(0.851,0.885)	1.058(1.052,1.064)
CVD risk > 20%	0.594(0.579,0.610)	0.674(0.660,0.688)	0.883(0.869,0.898)	1.062(1.056,1.068)
Charlson's Index < 3	0.650(0.630,0.671)	0.779(0.764,0.795)	0.810(0.796,0.824)	1.040(1.035,1.045)
Charlson's Index ≥ 3	0.597(0.583,0.612)	0.675(0.663,0.688)	0.923(0.909,0.936)	1.075(1.069,1.082)
No HT drug used	0.565(0.476,0.671)	0.616(0.550,0.690)	0.819(0.751,0.892)	1.022(0.979,1.067)
1 HT drug used	0.600(0.584,0.616)	0.698(0.685,0.711)	0.874(0.861,0.887)	1.062(1.056,1.067)
2 HT drugs used	0.599(0.580,0.620)	0.700(0.684,0.717)	0.876(0.859,0.893)	1.065(1.059,1.071)
3 or more HT drugs used	a 0.653(0.615,0.694)	0.729(0.695,0.764)	0.877(0.841,0.915)	+ 1.060(1.047,1.074)
Use of ACEI/ARB	0.621(0.595,0.647)	0.705(0.683,0.727)	0.878(0.855,0.902)	1.068(1.059,1.077)
Use of β-blocker	0.613(0.593,0.634)	0.715(0.698,0.732)	0.869(0.853,0.886)	1.063(1.057,1.069)
Use of CCB	0.594(0.580,0.608)	0.694(0.682,0.705)	0.871(0.860,0.883)	1.063(1.059,1.068)
Use of Diuretic	0.632(0.600,0.667)	0.718(0.692,0.745)	0.892(0.864,0.921)	1.061(1.051,1.071)
No statin used	0.601(0.589,0.613)	0.697(0.687,0.707)	0.876(0.865,0.886)	1.060(1.056,1.063)
Use of statin	0.630(0.589,0.675)	0.714(0.679,0.752)	0.825(0.792,0.859)	1.081(1.065,1.096)
0.4	0.6 0.8 1	0.4 0.6 0.8 1	0.6 0.8 1 1.2	1 1.05 1.1 1.15 1.2 Adjusted IRR

RAMP-HT = Risk Assessment and Management Program – Hypertension; SBP = Systolic Blood Pressure; LDL-C = Low Density Lipoprotein – Cholesterol; eGFR = estimated Glomerular Filtration Rate; BMI = Body Mass Index; CVD risk = Framingham 10-year CVD risk; HT = Hypertension; ACEI = Angiotensin Converting Enzyme Inhibitor; ARB = Angiotensin Receptor Blocker; CCB = Calcium Channel Blocker; †Controlled LDL-C is defined as LDL-C \leq 3.4 mmol/L for CVD risk \leq 20%, or LDL-C \leq 2.6 mmol/L for CVD risk \geq 20%.

eTable 1. Definition of the event outcome measures

Event	ICPC-2 codes*	ICD-9-CM codes#	Clinical parameters
Hypertension	K86, K87	NA	NA
CHD	K74-K76	410-414	NA
Heart Failure	K77	428	NA
Stroke	K89-K91	430-438	NA
ESRD	NA	585.5, 585.6, 586	eGFR < 15ml/min/1.73m ²
DM	T89, T90	NA	NA

ICPC-2 = International Classification of Primary Care-2; ICD-9-CM = International Classification of Diseases, Ninth Edition, Clinical Modification; CHD = Coronary Heart Disease; ESRD = End Stage Renal Disease; eGFR = Estimated Glomerular Filtration Rate; DM = Diabetes Mellitus; NA = Not Applicable

^{*}The ICPC-2 coding system is adopted in the public primary care clinics in Hong Kong to better capture the nature and variety of primary care patients' presenting problems.

 $^{^{\}text{\#T}}$ he ICD-9-CM coding system is used in the public hospital-based setting.

eTable 2. Data completion rates of matched RAMP-HT participants and usual care patients at baseline and 5-year follow-up

Time frame	At baseline		At 5 years			
Factor	RAMP-HT Participants (N = 108,045)	Usual Care Patients (N = 104,662)	RAMP-HT Participants (N = 108,045)	Usual Care Patients (N = 104,662)		
Socio-Demographic (n, %)	(
Gender	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Age	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Smoking Status	108,022 (99.98 %)	103,554 (98.94 %)	108,022 (99.98 %)	103,554 (98.94 %)		
Clinical Characteristics (n, %)						
SBP	108,045 (100.00 %)	104,321 (99.67 %)	100,155 (92.70 %)	80.59 % (84,352)		
DBP	108,045 (100.00 %)	104,321 (99.67 %)	100,155 (92.70 %)	80.59 % (84,344)		
Fasting Glucose	107,787 (99.76 %)	89,943 (85.93 %)	96,653 (89.46 %)	75.61 % (79,130)		
LDL-C	99.63 % (107,647)	87,696 (83.79 %)	97,900 (90.61 %)	76.06 % (79,602)		
TC/HDL-C Ratio	107,891 (99.86 %)	88,044 (84.12 %)	98,026 (90.73 %)	76.15 % (79,695)		
Triglyceride	107,917 (99.88 %)	88,577 (84.63 %)	98,035 (90.74 %)	76.22 % (79,778)		
BMI	107,816 (99.79 %)	73,181 (69.92 %)	84,900 (78.58 %)	57.08 % (59,740)		
eGFR	107,961 (99.92 %)	99,077 (94.66 %)	101,340 (93.79 %)	85.14 % (89,104)		
Charlson Comorbidity Index	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of ACEI/ARB	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of β-blocker	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of CCB	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of Diuretic	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of other anti-hypertensive drugs	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of Statin	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Use of Fibrate	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Frequency of Service Use†						
Overnight Hospitalization	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Accident and Emergency Department	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
Specialist Out-patient Clinic	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		
General Out-patient Clinic	108,045 (100.00 %)	104,662 (100.00 %)	108,045 (100.00 %)	104,662 (100.00 %)		

RAMP-HT = Risk Assessment and Management Program - Hypertension; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; LDL-C = Low Density Lipoprotein - Cholesterol; TC = Total Cholesterol; HDL-C = High Density Lipoprotein - Cholesterol; BMI = Body Mass Index; eGFR = Estimated Glomerular Filtration Rate; ACEI = Angiotensin Converting Enzyme Inhibitor; ARB = Angiotensin Receptor Blocker; CCB = Calcium Channel Blocker

Notes:

†Service use was measured 1) at baseline: from a year before baseline to baseline; 2) at 5 years: from baseline to last follow-up

eTable 3. Baseline characteristics between RAMP-HT participants and usual care patients before and after multiple imputation without fine stratification weightings

	Before multiple imput	ation	After multiple imputation				
Factor	RAMP-HT Participants (N = 108,045)	Usual Care Patients (N = 104,671)	RAMP-HT Participants (N = 108,045)	Usual Care Patients (N = 104,671)			
Demographics (n, %)	, ,						
Gender							
Female	64,050 (59.3 %)	59,466 (56.8 %)	59.3 % (64,050)	56.8 % (59,466)			
Male	43,995 (40.7 %)	45,205 (43.2 %)	40.7 % (43,995)	43.2 % (45,205)			
Age (mean±SD), year	$65.1{\pm}10.8\ (108{,}045)$	68.1±13.5 (104,671)	$65.1\pm10.8\ (108,045)$	68.1±13.5 (104,671)			
Smoking Status							
Non-Smoker	100,876 (93.4 %)	94,616 (91.4 %)	93.4 % (100,897)	91.4 % (95,645)			
Smoker	7,146 (6.6 %)	8,938 (8.6 %)	6.6 % (7,148)	8.6 % (9,026)			
Clinical Characteristics (mean±SD)							
SBP, mm Hg	136.9±15.5 (108,045)	136.3±17.3 (104,321)	136.9±15.5 (108,045)	136.3±17.3 (104,671)			
DBP, mm Hg	$76.7 \pm 10.6 \ (108,045)$	75.7±11.3 (104,321)	$76.7 \pm 10.6 \ (108,045)$	75.7±11.3 (104,671)			
Fasting Glucose, mmol/L	5.3±0.6 (107,787)	5.4±0.8 (89,943)	5.3±0.6 (108,045)	5.4±0.8 (104,671)			
LDL-C, mmol/L	3.2±0.8 (107,647)	3.2±0.8 (87,696)	$3.2\pm0.8\ (108,045)$	3.2±0.9 (104,671)			
TC/HDL-C Ratio	3.9±1.2 (107,891)	4.0±2.7 (88,046)	$3.9\pm1.2\ (108,045)$	4.0±2.9 (104,671)			
Triglyceride, mmol/L	1.4±0.9 (107,917)	1.5±0.9 (88,577)	$1.4\pm0.9\ (108,045)$	1.5±1.0 (104,671)			
BMI, kg/m ²	25.6±3.9 (107,816)	25.3±4.1 (73,181)	25.6±3.9 (108,045)	25.2±5.2 (104,671)			
eGFR (n, %)							
$\geq 60 \text{ml/min}/1.73 \text{m}^2$	104,870 (97.1 %)	92,615 (93.5 %)	97.1 % (104,948)	93.5 % (97,867)			
$< 60 \text{ml/min}/1.73 \text{m}^2$	3,091 (2.9 %)	6,462 (6.5 %)	2.9 % (3,097)	6.5 % (6,804)			
Charlson Comorbidity Index	3.0±1.2 (108,045)	3.2±1.3 (104,671)	3.0±1.2 (108,045)	3.2±1.3 (104,671)			
Number of HT drugs used (n, %)							
0	1,166 (1.1 %)	4,103 (3.9 %)	1,166 (1.1 %)	4,103 (3.9 %)			
1	57,819 (53.5 %)	56,446 (53.9 %)	57,819 (53.5 %)	56,446 (53.9 %)			
2	40,011 (37.0 %)	36,005 (34.4 %)	40,011 (37.0 %)	36,005 (34.4 %)			
≥3	9,049 (8.4 %)	8,117 (7.8 %)	9,049 (8.4 %)	8,117 (7.8 %)			
Use of ACEI/ARB (n, %)	22,480 (20.8 %)	19,013 (18.2 %)	22,480 (20.8 %)	19,013 (18.2 %)			
Use of β-blocker (n, %)	41,632 (38.5 %)	37,063 (35.4 %)	41,632 (38.5 %)	37,063 (35.4 %)			
Use of CCB (n, %)	78,260 (72.4 %)	71,649 (68.5 %)	78,260 (72.4 %)	71,649 (68.5 %)			
Use of Diuretic (n, %)	12,762 (11.8 %)	13,679 (13.1 %)	12,762 (11.8 %)	13,679 (13.1 %)			
Use of other anti-hypertensive drugs (n, %)	10,785 (10.0 %)	12,250 (11.7 %)	10,785 (10.0 %)	12,250 (11.7 %)			
Use of Statin (n, %)	9,460 (8.8 %)	6,651 (6.4 %)	9,460 (8.8 %)	6,651 (6.4 %)			
Use of Fibrate (n, %)	2,060 (1.9 %)	1,648 (1.6 %)	2,060 (1.9 %)	1,648 (1.6 %)			
Frequency of Service Use† (mean±S	D)						
Overnight Hospitalization	0.1±0.5 (108,045)	0.2±0.8 (104,671)	0.1±0.5 (108,045)	0.2±0.8 (104,671)			
Accident & Emergency Department	0.3±0.9 (108,045)	0.5±1.5 (104,671)	0.3±0.9 (108,045)	0.5±1.5 (104,671)			
Specialist Out-patient Clinic	1.5±2.7 (108,045)	1.8±3.2 (104,671)	1.5±2.7 (108,045)	1.8±3.2 (104,671)			
General Out-patient Clinic	5.5±2.3 (108,045)	5.8±3.1 (104,671)	5.5±2.3 (108,045)	5.8±3.1 (104,671)			

RAMP-HT = Risk Assessment and Management Program - Hypertension; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; LDL-C = Low Density Lipoprotein - Cholesterol; TC = Total Cholesterol; HDL-C = High Density Lipoprotein - Cholesterol; BMI = Body Mass Index; eGFR = Estimated Glomerular Filtration Rate; ACEI = Angiotensin Converting Enzyme Inhibitor; ARB = Angiotensin Receptor Blocker; CCB = Calcium Channel Blocker; SD = Standard Deviation

Notes

[†] Service use was measured from a year before baseline to baseline

eTable 4. Frequency of RAMP-HT service attendances among RAMP-HT participants

RAMP-HT Participants (N = 108,045)

	Nurse assessment	Nurse intervention	Doctor intervention
Frequency (n, %)			
1	40,031 (37.1 %)	13,823 (12.8 %)	1,291 (1.2 %)
2	37,422 (34.6 %)	3,170 (2.9 %)	821 (0.8 %)
3	18,008 (16.7 %)	1,153 (1.1 %)	546 (0.5 %)
4	7,152 (6.6 %)	559 (0.5 %)	307 (0.3 %)
≥ 5	5,432 (5.0 %)	633 (0.5 %)	505 (0.5 %)
Mean±SD	2.1±1.1	0.3±0.8	0.1±0.6

RAMP-HT = Risk Assessment and Management Program – Hypertension; SD = Standard deviation

eTable 5. Patients' characteristics between RAMP-HT participants and usual care patients at 5-year follow-up after fine stratification weightings

	At 5 year		
Characteristics	RAMP-HT Participants (N = 108,045)	Usual Care Patients (N = 104,662)	SMD
Socio-Demographic (n, %)			
Gender			0.003
Female	62,277 (57.6 %)	60,497 (57.8%)	
Age (mean±SD), year	71.3±12.3	71.3±13.5	0.003
Smoking Status			0.009
Smoker	6,913 (6.4 %)	6,858 (6.6%)	
Clinical Characteristics (mean±SD)			
SBP, mm Hg	132.5±16.3	134.7±17.1	0.143
DBP, mm Hg	73.5±11.4	74.5 ± 11.3	0.090
Fasting Glucose, mmol/L	5.5 ± 1.0	5.7±1.1	0.144
LDL-C, mmol/L	2.7 ± 0.8	$2.8{\pm}0.9$	0.118
TC/HDL-C Ratio	3.6 ± 1.7	3.7 ± 1.2	0.079
Triglyceride, mmol/L	1.4 ± 0.8	1.4 ± 0.9	0.018
BMI, kg/m ²	25.5±4.2	25.5±4.5	0.016
eGFR (%, n)			0.083
$\geq 60 \text{ml/min}/1.73 \text{m}^2$	94,563 (93.3 %)	81,150 (91.1%)	
$< 60 \text{ml/min}/1.73 \text{m}^2$	6,777 (6.7 %)	7,947 (8.9%)	
Charlson Comorbidity Index	3.9±1.6	4.1 ± 1.7	0.109
Number of HT drugs used (n, %)			0.025
0-1	56,703 (50.9 %)	50,317 (49.7 %)	
≥2	51,342 (49.1 %)	49.7 % (50.3 %)	
Use of ACEI/ARB (n, %)	34,452 (31.9 %)	33,429 (31.9%)	0.001
Use of β-blocker (n, %)	38,289 (35.4 %)	37,593 (35.9%)	0.01
Use of CCB (n, %)	81,908 (75.8 %)	77,925 (74.5%)	0.031
Use of Diuretic (n, %)	9,542 (8.8 %)	9,640 (9.2%)	0.013
Use of other anti-hypertensive drugs (n, %)	11,661 (10.8 %)	10,651 (10.2%)	0.020
Use of statin (n, %)	42,530 (39.4 %)	34,395 (32.9%)	0.136
Use of fibrate (n, %)	3,093 (2.9 %)	3,048 (2.9%)	0.003
Frequency of Service Use† (mean±SD)			
Overnight Hospitalization	1.1±2.9	1.9 ± 3.3	0.270
Accident & Emergency Department	1.9±5.4	2.8 ± 4.9	0.199
Specialist Out-patient Clinic	9.0±13.1	10.9 ± 13.9	0.143
General Out-patient Clinic	21.0±13.9	22.3±14.0	0.099

RAMP-HT = Risk Assessment and Management Program - Hypertension; SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure; LDL-C = Low Density Lipoprotein - Cholesterol; TC = Total Cholesterol; HDL-C = High Density Lipoprotein - Cholesterol; BMI = Body Mass Index; eGFR = Estimated Glomerular Filtration Rate; ACEI = Angiotensin Converting Enzyme Inhibitor; ARB = Angiotensin Receptor Blocker; CCB = Calcium Channel Blocker; SD = Standard Deviation, SMD = standardized mean difference

Notes:

†Uses of service use were measured from baseline SMD<0.2 indicates balance between groups.

eTable 6. Sensitivity analyses on comparisons of all outcome event, cardiovascular disease, end stage renal disease, diabetes mellitus, and all-cause mortality between RAMP-HT participants and usual care patients

	Sensitiv	ity analys	es																					
	(1)			(2)			(3)			(4)			(5)			(6)			(7)			(8)		
Event	ARR	HR†	NNT	ARR	HR†	NNT	ARR	HR†	NNT	ARR	HR†	NNT	ARR	HR†	NNT	ARR	HR†	NNT	ARR	HR†	NNT	ARR	HR†	NNT
All outcome event	12.0%	0.61*	10	9.5%	0.59*	12	14.5%	0.55*	9	12.0 %	0.59*	12	9.2%	0.60*	12	12.0%	0.57*	10	14.5%	0.58*	11	14.5%	0.58*	11
CVD	6.4%	0.66*	23	5.8%	0.62*	17	8.0%	0.59*	15	7.4%	0.61*	17	5.8%	0.62*	17	7.4%	0.59*	15	8.0%	0.62*	16	8.0%	0.62*	16
CHD	1.9%	0.71*	65	2.0%	0.66*	47	2.6%	0.64*	41	2.6%	0.65*	46	2.1%	0.66*	46	2.6%	0.63*	41	2.6%	0.66*	47	2.6%	0.66*	47
Heart Failure	2.5%	0.56*	62	2.1%	0.54*	52	3.2%	0.50*	38	2.7%	0.53*	53	2.2%	0.53*	49	2.7%	0.51*	44	3.2%	0.54*	49	3.2%	0.54*	49
Stroke	3.2%	0.67*	80	3.0%	0.63*	35	4.0%	0.61*	30	3.7%	0.63*	36	2.8%	0.64*	36	3.7%	0.61*	32	4.0%	0.64*	36	4.0%	0.64*	36
ESRD	1.3%	0.54*	95	0.7%	0.62*	155	1.6%	0.50*	79	1.4%	0.54*	119	0.7%	0.63*	158	1.3%	0.52*	93	1.6%	0.54*	105	1.6%	0.54*	105
DM	4.3%	0.78*	91	4.0%	0.79*	33	4.6%	0.70*	23	6.3%	0.76*	28	4.5%	0.78*	30	6.3%	0.67*	19	4.6%	0.82*	41	4.6%	0.83*	41
All-Cause Mortality	8.2%	0.55*	21	6.0%	0.54*	20	10.0%	0.48*	14	7.4%	0.55*	22	5.6%	0.57*	22	7.4%	0.53*	18	10.0%	0.52*	17	10.0%	0.52*	17
CVD Mortality	3.0%	0.55*	61	2.4%	0.50*	47	3.9%	0.46*	32	3.1%	0.51*	51	2.3%	0.53*	50	3.1%	0.49*	41	3.9%	0.51*	43	3.9%	0.51*	43
Non-CVD Mortality	5.3%	0.55*	62	3.5%	0.56*	32	6.1%	0.49*	21	4.3%	0.58*	59	3.3%	0.59*	35	4.3%	0.56*	30	6.0%	0.53*	45	6.0%	0.53*	45

^{(1) =} Excluded patients with less than 1-year follow-up; (2) = Multiple imputation with one-to-one propensity score matching; (3) = Multiple imputation without propensity score matching or weightings; (4) = Fine stratification weightings without multiple imputation; (5) = Propensity score matching only without multiple imputation; (6) = Complete case analysis; (7) = 25 Multiple imputations with propensity score fine stratification weightings; (8) = 50 Multiple imputations with propensity score fine stratification weightings

RAMP-HT = Risk Assessment and Management Program - Hypertension; CVD = Cardiovascular Disease; CHD = Coronary Heart Disease; ESRD = End Stage Renal Disease; DM = Diabetes Mellitus; ARR = Absolute Risk Reduction; HR = Hazard Ratio; NNT = Number Needed to Treat;

Notes:

† Hazard ratios were adjusted by gender, age, smoking status, SBP, DBP, fasting glucose, LDL-C, TC/HDL-C ratio, triglyceride, BMI, eGFR, Charlson Comorbidity Index and the usages of ACEI/ARB, β-blocker, CCB, Diuretic, other anti-hypertensive drugs, statin and fibrate at baseline by multivariable Cox proportional hazard regression/multivariable Cox proportional hazard regression with fine stratification weighting, as appropriate

^{*} P-value < 0.05.

eTable 7. Sensitivity analyses on comparisons of service use between RAMP-HT participants and usual care patients

	Sensit	Sensitivity analyses														
	(1)		(2)		(3)		(4) (5		(5)	(5)		(6)			(8)	
Frequency of Event during the Period	Rate	IRR†	Rate	IRR†	Rate	IRR†	Rate	IRR†	Rate	IRR†	Rate	IRR†	Rate	IRR†	Rate	IRR†
Overnight Hospitalization	-12.4	0.62*	-12.6	0.61*	-21.7	0.57*	-17.0	0.62*	-12.1	0.62*	-17.2	0.59*	-13.3	0.60*	-13.3	0.60*
AED Attendance	-13.1	0.72*	-13.6	0.70*	-24.6	0.68*	-19.8	0.72*	-13.5	0.72*	-20.1	0.70*	-14.1	0.70*	-14.0	0.70*
SOPC Attendance	-17.3	0.88*	-23.5	0.85*	-39.7	0.85*	-41.2	0.85*	-22.5	0.85*	-42.6	0.83*	-18.1	0.87*	-18.1	0.87*
GOPC Attendance	14.6	1.05*	0.3	1.05*	9.2	1.06*	-5.4	1.04*	-1.7	1.04*	-8.5	1.04*	15.8	1.06*	15.7	1.06*

^{(1) =} Excluded patients with less than 1-year follow-up; (2) = Multiple imputation with one-to-one propensity score matching; (3) = Multiple imputation without propensity score matching or weightings; (4) = Fine stratification weightings without multiple imputation; (5) = Propensity score matching only without multiple imputation; (6) = Complete case analysis; (7) = 25 Multiple imputations with propensity score fine stratification weightings

RAMP-HT = Risk Assessment and Management Program - Hypertension; AED = Accident and Emergency Department; SOPC = Specialist Outpatient Clinic; GOPC = General Outpatient Clinic; IRR = Incidence Rate Ratio

Notes:

The unit for incidence rate is Cases/100 Person Years.

multivariable negative binomial regression/multivariable negative binomial regression with fine stratification weighting, as appropriate

^{*} P-value < 0.05.

[†] All incidence rate ratios were adjusted by gender, age, smoking status, SBP, DBP, fasting glucose, LDL-C, TC/HDL-C ratio, triglyceride, BMI, eGFR, Charlson Comorbidity Index and the usages of ACEI/ARB, β-blocker, CCB, Diuretic, other anti-hypertensive drugs, statin and fibrate, and the corresponding number of service use at baseline by