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How this fits in

Multimorbidity, high complexity, and chronicity of disease, ask for multidisciplinary management in a care continuum. Preferably, care evaluations incorporate the entire continuum, including primary and hospital care. We evaluated the cardiovascular risk management continuum from GP to hospital and vice versa via linkage of health data sources, as an example of a complex multidisciplinary care continuum. Efforts have to be made to improve registration of cardiovascular risk factors in primary care as well as communication on findings and actionable suggestions for follow-up from specialist to general practitioner to bridge the gap in the CVRM continuum.

Abstract

Background: Multimorbidity and chronicity of disease ask for multidisciplinary management in a care continuum, integrating primary care and hospital care services.

Aim: To evaluate cardiovascular risk management (CVRM) via linkage of health data sources, as an example of a multidisciplinary continuum within a learning healthcare system (LHS).

Design and setting: In this prospective cohort study we linked data from the Utrecht Cardiovascular Cohort (UCC) to the Julius General Practitioners Network (JGPN) database. UCC offers structured CVRM at referral to the UMC Utrecht. JGPN consists of EHR data from referring GPs.

Methods: We extracted the cardiovascular risk factors for each patient 13 months before referral (JGPN), at UCC inclusion and during 12 months follow-up (JGPN). We assessed registration of risk factors, detection of risk factor(s) requiring treatment at UCC, communication of risk factors and actionable suggestions from the specialist to the GP, and change of management during follow-up.

Results: In 52% of patients, ≥1 risk factor was registered (i.e., extractable from structured fields within routine care health records) before UCC. In 12-72% of patients risk factor(s) existed requiring (change or start of) treatment at UCC inclusion. Specialist communication included the complete risk profile in 67% of letters, but lacked actionable suggestions in 86%. In 29% of patients at least one risk factor was registered after UCC. Change in management in GP records was seen in 21-58% of them.

Conclusion: Evaluation of a multidisciplinary LHS is possible via linkage of health data sources. Efforts have to be made to improve registration in primary care as well as communication on findings and actionable suggestions for follow-up to bridge the gap in the CVRM continuum.

Keywords: learning healthcare system, continuity of care, cardiovascular risk management

Introduction

Modern medical practice, with a growing and aging population and high quality care, is characterized by multimorbidity, high complex diseases, and a high proportion of chronic diseases.(1, 2) This asks for multidisciplinary collaboration and communication between all different caretakers, forming a care continuum.(3) Evidence for clinical practice is derived from medical research. Classically, medical research is conducted outside routine practice in randomized controlled trials and dedicated cohorts with strict inclusion and exclusion criteria.(4) Because our real world patient does not continuously fit these criteria, generated evidence does not always translate to daily practice (5). Within a learning healthcare system (LHS), data from daily practice is used as input for analysis, interpretation and feedback.(6) Compared to conventional medical research, LHS-based research is potentially more efficient in both time and costs and is not hampered by selection and decreased generalizability due to strict inclusion and exclusion criteria. Preferably, the LHS incorporates the entire care continuum.(4, 7)

Cardiovascular diseases (CVD) are a good example of high complex, multi-morbid, and chronic diseases.(8) Prevention of CVD is in basis the same for all patients: life-long cardiovascular risk factor management (CVRM). In the Netherlands, general practitioners (GPs) usually have a longstanding relationship with their patients. Therefore, chronic disease management, such as CVRM, is placed in their portfolio. CVRM guidelines provide various recommendations for diagnosis, treatment, and referral. If necessary, patients are referred to secondary or tertiary care for further evaluation of their cardiovascular condition. The responsibility of the CVRM can be transferred to a hospital specialist, and back to the GP after cessation of hospital care.(9) Together, all caretakers contribute to a multidisciplinary CVRM continuum.

The aim of this study was to evaluate the CVRM continuum via linkage of health data sources, as an example of a multidisciplinary LHS.

Methods

Study design

We conducted a prospective cohort study with data from the ongoing Utrecht Cardiovascular Cohort (UCC) and Julius General Practitioner Network (JGPN).(10, 11)

Data source

The Centre of Circulatory health of the University Medical Center (UMC) Utrecht has initiated the UCC in 2016. In short, UCC is an ongoing prospective cohort study, collecting routine clinical data from patients referred for a CVD (risk factor) to the UMC Utrecht.(10) Informed consent for linkage with external parties was obtained in the UCC. The UCC has been approved by the local Institutional Review Board. The JGPN database consists of routine care data from over ten years of a dynamic cohort of around 370,000 individuals registered with the participating GPs from the city of Utrecht and its vicinity.(11) Informed consent was waived for JGPN participation based on the "law on the medical consultation"(Dutch: WGBO) exception rules for research with medical care data where (i) patients are anonymous, (ii) there is no breach of personal integrity, (iii) research cannot be performed without this data, (iv) research serves a common benefit and (v) patients are informed on the usage, are provided an opportunity to opt-out, and do not explicitly object.(12) All JGPN practices were obliged to inform their patients on the JGPN database and the opt-out procedure.(11)

Participants

All UCC patients that provided informed consent for linkage with third party registries that were also part of the JGPN database were eligible for this analysis. We requested information on the cardiovascular risk profile - smoking, alcohol use, BMI, blood pressure (BP), lipids, glucose, renal function, physical activity, cardiovascular history, and medication – for each patient between 13 months before referral to the UMC Utrecht (JGPN), at referral (UCC) and 12 months after referral (JGPN).(9)

To combine UCC and JGPN data sources, we linked the UCC patients to their JGPN records at an individual patient level using a trusted third party (TTP). The TTP received UCC Pseudo ID's plus identifying information and matched them with JGPN Pseudo ID's. TTP supplied the JGPN data manager with JGPN Pseudo IDs, who added requested JGPN variables to the dataset. This was sent back to TTP, who then removed JGPN Pseudo IDs and added UCC Pseudo IDs. This dataset was provided to the UCC data manager, who then added requested UCC variables to the set and provided the complete dataset to the researchers.

Measurement characteristics

JGPN data was extracted from structured fields within the general practitioners' electronic health records (EHRs). Prescribed cardiovascular medication was extracted from the electronic prescription system via predefined Anatomical Therapeutic Chemical codes (Supplementary Table S1). UCC data was collected via a questionnaire, biometric measurements and blood draw in routine care at the UMC Utrecht, all registered in predefined fields within the EHR. (10) All variables and their source in JGPN and UCC are listed in Supplementary Table 2.

Outcome measurements

Risk factor registration

First, we assessed the registration of the risk factors: smoking, alcohol use, BMI, systolic blood pressure (SBP), LDL-c, glucose, renal function, and physical activity in JGPN before and after UCC inclusion. We defined the variable *"at least one risk factor registered in JGPN"* as *"yes"* if at least one of these factors was registered in JGPN. Differences in individual risk factor levels were compared between patients with any risk factor registered to patients with *"none"* of the risk factors registered in JGPN before referral to UCC.

Risk factor target attainment

Second, based on the UCC risk profile, patients were stratified according to the European Society of Cardiology risk categories.(13) Then the patient's target status – either on or off target – was determined dependent on their risk category. The BP target was below140/90mmHg in every risk category. The LDL-c target was <1.8mmol/L for the very-high-risk category and <2.5mmol/L for the high-risk category. The HbA1c target was <53mmol/L for patients with type II diabetes.

Added value of UCC to detect risk factors with indication for treatment

Third, we assessed the added value of UCC to detect hypertension, dyslipidaemia, and diabetes. The added value was defined as the proportion of patients with a de novo condition detected in the UCC plus the patients with known conditions but off-target measurements. Patients without reported hypertension, dyslipidemia or diabetes but with an off-target measurement were defined as *"newly diagnosed"*. For diabetes, the threshold for newly diagnosed diabetes was an HbA1c>48mmol/mol.

Communication between the specialist and general practitioner

Fourth, in the specialist letter after the UCC consult, we evaluated the level of completeness of the cardiovascular risk profile, and if the specialist specifically advised follow-up action(s) for CVRM.

Follow-up

Last, we assessed follow-up and change of CVRM after the UCC consult of BP, LDL-c, and HbA1c. Change of CVRM was defined as a change in the absolute level of the risk factor and/or a change in medication prescription when comparing medication use reported in JGPN before and UCC to the follow-up measurement. We defined positive change (risk factor level decreased and/or medication was commenced/changed), stable off target (no change in management and still off target) and stable on target (no change in management, still on target).

Statistical analyses

Statistical analyses were conducted in R studio (version 3.4.1, 2017, The R Foundation for Statistical Computing). We used student t- tests to compare normally distributed continuous variables and Pearson chi square or fisher's exact test where appropriate for proportions.

Results

Participants

Out of 2,427 UCC patients (included from January 2016 up to May 14th 2019), 751 (31%) could be identified in the JGPN database (Figure 1), of which 231 (31%) were at high risk and 520 (69%) at very high risk for CVD according to the ESC classification(8). All patients had an indication for annual CVRM check-up.(8) In 112 patients (15%) the general practitioner was listed as the lead caretaker for CVRM, in 25 (3%) the (cardiovascular) specialist, and in 614 (82%) no lead caretaker was registered in the JGPN database.

The CVRM continuum

Risk factor registration

Before UCC, ≥1 risk factors were registered for 392 patients in JGPN (52%) (Figure 1). Patients' height (6%) was registered the least (10%), SBP the most (43%) (Table 1). Patients with registered risk factors in JGPN before UCC inclusion showed a more unfavourable risk profile (Table 2): mean age, BMI, and SBP were higher and eGFR was lower compared to patients without registered risk factors. In both groups we found similar proportions of women and patients with coronary heart disease, chronic heart failure, stroke, and peripheral artery disease.

Risk factor target attainment, added value of UCC and follow-up: blood pressure

In UCC, 410 (55%) patients required change or start of BP lowering treatment (off target measurement) (Figure 2A). Of the 751 patients, ≥1 risk factors were registered in 221 (29%) patients at follow-up in JGPN after UCC. More patients that were off target were followed-up (150 out of 410, 37%) compared to those that were on target (71 out of 341, 21%). Of patients that were off target, 71 (47%) improved at follow-up.

Risk factor target attainment, added value of UCC and follow-up: LDL-cholesterol

In UCC, 542 (72%) patients required change or commencement of LDL-c lowering treatment (off target measurement) (Figure 2B). Of the 751 patients, ≥1 risk factors were registered in 155 (21%) patients at follow-up in JGPN after UCC. Less patients that were off target were followed-up (102 out of 542, 14%) compared to those that were on target (53 out of 209, 21%). Of patients that were off target, 21 (21%) improved.

Risk factor target attainment, added value of UCC and follow-up: blood glucose

In UCC, 74 (of 595, 12%) patients required change or commencement of blood glucose lowering treatment (off target measurement or new diagnosis of Diabetes Mellitus) (Figure 2C). Of the 595 patients, 176 (30%) were followed-up. More patients that were off target were followed-up in JGPN after UCC (26 out of 74, 35%) compared to those that were on target (150 out of 521, 29%). Of patients that were off target, 15 (58%) improved.

Communication between the specialist and general practitioner

We assessed specialist letters to the GP in a subset of 311 patients. The most frequent reasons for referral to the specialist were analysis of coronary heart disease (n= 74, 25%) and analysis of cognitive impairment (n= 60, 20%). All patients were referred to the UMC Utrecht by their GP. The specialist of referral reported back to the general practitioner on 95% of the consults. In 8% of these letters, none of the cardiovascular risk factors were reported, in 29% one or more were missing (mostly lipids), and in 63% a complete risk profile was reported. The CVRM profile was more often reported in patients in whom risk factor management required a change, i.e., changing of treatment or starting treatment. In 43 letters (14%) the specialist specifically suggested follow-up action(s) for the cardiovascular risk factors by the general practitioner (such as: “please follow-up blood pressure”), insinuating a leadership role for the general practitioner regarding CVRM.

Discussion

Summary

In this study we evaluated the patient trajectory in the CVRM continuum as an example of a multidisciplinary LHS. Structured assessment of the risk profile in tertiary care has added value: many patients required (start or change of) treatment of a risk factor. Yet, only few specialists specifically highlight the CVRM in their letter to the general practitioner and follow-up in general practice might therefore be lacking. Based on our combined hospital/general practitioner data it is unclear in most patients who is lead caretaker regarding CVRM.

Strengths and limitations

The presented project was a proof-of-concept of how a multidisciplinary LHS can be evaluated via linkage of data sources. Because our population is a tertiary centre population 31% of patients were from the Utrecht area and could be linked. If more data sources would be made more easily linkable, such as other hospital data and/or pharmacy data, this would improve some of the follow-up gaps, and increase power of the analyses. It could very well be that (part of) this high risk population , were under follow-up in another hospital. Furthermore, we were restricted to patients that provided informed consent for linkage of UCC to external parties.(14) For an LHS, current ethical and legislative frameworks do not suffice for they are based on the classical separation of science and care. Initiatives that focus on the design of a new framework, that empowers LHS developments but safeguards integrity of patients, are arising.(15)

Specifically to CVRM, we extensively discussed the timeframe for follow-up Since new medication should be evaluated within 3 months (9), we should have caught this follow-up visit in our extraction. Also, the minus 13 to plus 12 months range allowed us to retrieve information on yearly CVRM.

To construct target attainment prevalence for hypertension, dyslipidaemia and diabetes, we defined above target BP, LDL-c and HbA1c as absolute measurements in combination with the ESC risk classification. However, the guidelines also allows for a relative target attainment, for example an LDL-c reduction of 50% compared to the first measurement.(13) Because we did not have information on the first measurement on which the diagnosis was defined, we could not construct these relative target attainment measures. This might have resulted to false off target classification.

Comparison with existing literature

In our analysis, we found room for improvement in registration and communication of CVRM . Organized identification of eligible patients is essential for establishment of a care continuum.

Studies on cardiac rehabilitation confirm this hypothesis: uptake of rehabilitation programs is highly dependent on the identification of eligible patients after manifestation of the event.(16, 17) Structured registration of the risk factors in all EHRs (GP or hospital), enabling automated extraction of relevant information of a specific patient population, is essential for an LHS. In our hospital (UCC) we organized identification of eligible patients and safeguarded uniformity of registration by providing an organizational structure to all departments providing care for patients with CVDs.(10) Yet, registration of data in JGPN is not uniformly organized and based on structured-field-only extractions. It is known that much of clinically relevant data is still registered in unstructured clinical notes.(18) Structured collection and registration similar to UCC and also more advanced methods such as data mining of free text could be incorporated to improve data completeness and quality.(18) Lastly, communication between specialists and general practitioners mostly runs through letters. Yet, recommendations on the next steps in treatment or follow-up and even vital information are frequently absent in these letters.(19, 20) Structured and timely communication between caretakers is essential for continuity of care and associated with less adverse outcomes.(21) Communication should be standardized and at least contain factor levels including interpretation, suggestions for follow-up and (transfer of) CVRM leadership. Potential solutions are a template letter or automatically generated letters.(21)

Implications for research and practice

In conclusion, evaluation of a multidisciplinary transmural LHS is possible via linkage of health data sources. Our results indicate that structured assessment of risk factors has added value for detecting risk factor(s) requiring treatment. Organized identification of eligible patients, structured registration in primary care and secondary care in structured fields as well as communication on findings and actionable suggestions for follow-up need to be improved to solve the gap in the CVRM continuum. We suggest strong leadership of the general practitioner to coordinate this continuum.

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Competing interests

All authors declare no conflicts of interest.

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Figure captions

Figure 1. Flowchart of patient selection and risk factor assessment overview

Figure 2. The multidisciplinary care continuum for blood pressure, LDL-cholesterol and glucose management

Table 1. Percentage of registration of factors in JGPN

Risk factors	Before UCC (%) Total n = 751	After UCC (%) Total n = 751
Smoking	27	17
Alcohol use	21	13
Length	6	4
Weight	27	19
BMI	25	17
Family history of CVD <60yrs	10	6
Physical activity	20	13
Systolic blood pressure	43	29
Diastolic blood pressure	43	29
HDL- cholesterol	37	21
LDL- cholesterol	36	21
Triglycerides	37	21
Total cholesterol	37	21
Glucose (fasting or non – fasting)	43	27
eGFR	46	27
Number of risk factors available*		
0	48	71
1-3	28	22
4-6	24	15

* From: smoking, alcohol, BMI, systolic blood pressure, low-density lipoprotein, glucose, renal function, physical activity

Legend – JGPN: Julius General Practitioners Network, UCC: Utrecht Cardiovascular Cohort, BMI: body mass index, CVD: cardiovascular disease, HDL: high-density lipoprotein, LDL: low-density lipoprotein, eGFR: estimated glomerular filtration rate,

Table 2. Risk factor profile measured at UCC inclusion

	None of RFX registered in JGPN before referral n = 359 (48%)	At least one of RFX registered in JGPN before referral n = 392 (58%)
Age (years, mean (sd))	52 (18)	65 (16)
Women (n= (%))	190 (53)	189 (48)
Anthropometry		
BMI (kg/m^2, mean(sd))	25 (5)	28 (6)
Height (cm, mean(sd))	174 (14)	171 (11)
Weight (kg, mean(sd))	78 (18)	80 (18)
Lifestyle		
Current smoking (missing 12%)	43 (14)	38 (11)
Current alcohol use (missing 12%)	192 (63)	188 (53)
Physical activity (minutes/week) (missing 25%)	1881 (1285)	1666 (1233)
Laboratory measurements		
Systolic blood pressure (mmHg, mean(sd))	133 (20)	146 (24)
Diastolic blood pressure (mmHg, mean(sd))	79 (12)	81 (13)
HDL- cholesterol	1.4 (0.4)	1.4 (0.5)
LDL- cholesterol	3.2 (1.3)	3.1 (1.3)
Triglycerides	1.6 (1.2)	2.0 (2.4)
Total cholesterol	5.3 (1.5)	5.3 (1.6)
eGFR (1.73/ml/min, mean (sd))	91 (25)	79 (21)
HbA1C (mmol/mol, mean (sd))	38 (10)	53 (12)
History of CVD		
Coronary heart disease	28 (7.8)	83 (21)
Chronic heart failure	28 (7.8)	30 (7.7)
Stroke	34 (9.5)	65 (16.6)
Peripheral artery disease	19 (5.3)	46 (12)

Legend – RFX: risk factor JGPN: Julius General Practitioners Network, UCC: Utrecht Cardiovascular Cohort, BMI: body mass index, CVD: cardiovascular disease, HDL: high-density lipoprotein, LDL: low-density lipoprotein, eGFR: estimated glomerular filtration rate, HbA1c: glycated hemoglobin.

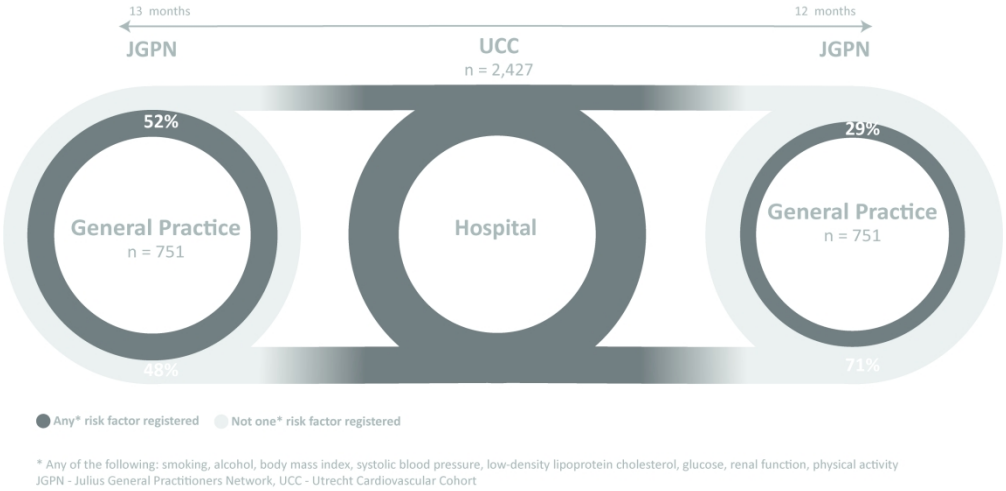

Figure 1. Flowchart of patient selection and risk factor assessment overview

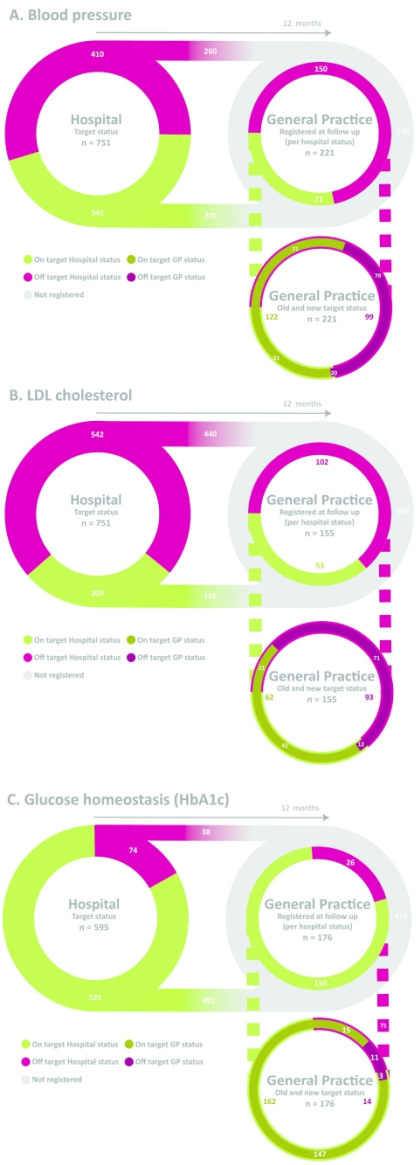

Figure 2. The transmural care continuum for blood pressure, LDL-cholesterol and glucose management

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