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Chronic disease multimorbidity transitions across healthcare interfaces and associated costs: a clinical-linkage database study

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ABSTRACT

Objective: To investigate multimorbidity transitions from general practice populations across healthcare interfaces and the associated healthcare costs.

Design: Clinical-linkage database study.

Setting: Population (N=60 660) aged 40 years and over registered with 53 general practices in Stoke-on-Trent.

Participants: Population with six specified multimorbidity pairs were identified based on hypertension, diabetes mellitus (DM), coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF) and chronic kidney disease (CKD).

Main outcomes measures: Chronic disease registers were linked to accident and emergency (A&E) and hospital admissions for a 3-year time period (2007–2009), and associated costs measured by Healthcare Resource Groups. Associations between multimorbid groups and direct healthcare costs were compared with their respective single disease groups using linear regression methods, adjusting for age, gender and deprivation.

Results: In the study population, there were 9735 patients with hypertension and diabetes (16%), 3574 with diabetes and CHD (6%), 2894 with diabetes and CKD (5%), 1855 with COPD and CHD (3%), 754 with CHF and COPD (1%) and 1425 with CHF and CKD (2%). Transition, defined as at least one episode in each of the 3-year time periods, was as follows: patients with hypertension and DM had the fewest transitions in the 3-year time period (37% A&E episode and 51% hospital admission), but those with CHF and CKD had the most transitions (67% A&E episode and 79% hospital admission). The average 3-year total costs per multimorbid patient for A&E episodes ranged from £69 to £166 and for hospital admissions ranged from between £2289 and £5344. The adjusted costs were significantly higher for all six multimorbid groups compared with their respective single disease groups.

Conclusions: Specific common multimorbid pairs are associated with higher healthcare transitions and differential costs. Identification of multimorbidity type and linkage of information across interfaces provides opportunities for targeted intervention and delivery of integrated care.

ARTICLE SUMMARY

Article focus

- In the population, there are large numbers of people who suffer from two or multiple chronic diseases at the same time.
- Most of the current evidence has focused on the impact of multimorbidity on health status and very few have investigated the transitions across healthcare and the associated costs.
- While individual chronic diseases have been shown to be associated with high healthcare costs, whether specific multimorbid combinations have differential healthcare transitions and healthcare costs is unknown.

Key messages

- Specific multimorbid pairs are associated with different levels of healthcare transitions and costs relating to accident and emergency and hospital admissions.
- Chronic disease pairs indicate the population-level multimorbidity 'severity', as indicated by transitions and costs, with a range from diabetes and hypertension ('low severity'), diabetes and heart disease, diabetes and chronic kidney disease (CKD), chronic obstructive pulmonary disease (COPD) and heart disease, heart failure and COPD, to heart failure and CKD ('high severity').
- Identification of multimorbidity type and linkage of information across healthcare interfaces provides opportunities for targeted intervention and delivery of cost-effective integrated care.

Strengths and limitations of this study

- The study was based on large-scale data linking chronic disease registers from general practices to accident and emergency episodes and hospital admissions.
- The study highlights the innovative potential of linkage data between healthcare interfaces to inform healthcare delivery.
- The study uses a specific but limited number of common chronic diseases to illustrate the approach to using linked data within a single large region of the UK.

BACKGROUND

Multimorbidity is an individual's experience of two or more illnesses at the same time. In ageing populations, the numbers of people with such multimorbidity will increase substantially, and it is estimated that there are up to 20% of the British population (4 million people) who may experience such multimorbidity,[1] with a projected further increase of 37% in the England and Wales population aged 50 years and over by the year 2031. This means that the current focus of healthcare delivery on specific disease-focus outcomes will have to be complemented by a Public Health priority focusing on multimorbidity in older populations.

Current evidence on multiple disease in the same person has shown that this is a common problem, which has a high impact on an individual's health and on the use of healthcare resources.[2–4] However, people may also experience transitions, that is, healthcare changes from general practice to different healthcare interfaces such as Accident and Emergency (A&E) or hospital care, especially as delivery of chronic disease is orientated around individual healthcare pathways. Once a person experiences a number of different diseases, the issue then becomes how the person interacts with different healthcare interfaces. Current research has shown that in specific settings, such as general practice[5] or hospitals, multimorbidity is common in the encounters that are present in the disease-care pathways.[6 7] However, there are little empirical data on how multimorbidity influences transitions across different healthcare interfaces and whether specific multimorbidity combinations are more likely to be associated with higher healthcare presentations, such as A&E episodes or hospital admissions. Routine coding of such patients' encounters now occurs in clinical practice, A&E and hospitals, and technological developments allow the linkage of clinical information across these interfaces.[8] These developments allow for the potential for targeted prevention and new models of healthcare interventions for patients who experience multiple chronic diseases at the same time.

The other key area of focus is how cost-effective care pathways can be developed. By understanding how multimorbidity influences interface presentation and the associated healthcare costs, it can be explored as to whether healthcare costs can be 'benchmarked' for specific conditions and combinations of conditions.[9] Currently, much of the chronic disease healthcare delivery pathways has aligned along single-disease lines, for example, diabetes, chronic obstructive airways disease or heart failure. So the potential range of multimorbidity model of care could range from joint clinics (eg, diabetes and renal) to the holistic clinical assessment conducted by elderly care physicians.[10 11] However, one could argue that the next simple step from single disease pathway care to a multimorbidity approach is understanding pair combinations which link to at least two individual disease care pathways, and which we use in this study by selecting common chronic diseases in the older population. Using a large linkage dataset, we investigated the clinical hypothesis as to whether specific chronic disease multimorbidity pairs are associated with differences in healthcare transitions and associated healthcare costs, and compared it with populations with only one of the respective matched conditions.

METHODS

Design

The design of the study was a cross-sectional clinical linkage study of the population aged 40 years and over on chronic disease registers to transition data on A&E episodes or hospital admission in a 3-year time period (1 January 2007 to 31 December 2009).

Setting

The setting is an urban population of around 240 000 which focuses around the city of Stoke-on-Trent, which is one of the most deprived in England and Wales and has some of the highest levels of chronic disease prevalence, and over half of the areas are in the most deprived 20% in England.[12]

Clinical linkage datasets

Chronic disease registers

The local Primary Care Trust oversees 53 general practices, all of which have been participating in a national and local quality improvement framework[13] for specific chronic diseases, as well as in recording clinical data through regular data audits and checks. For specified conditions, using the Read Code classification,[14] general practitioners and their teams had recorded clinical data on disease registers for their population. These practices contributed to the construction of a clinical database, which for this study covers a 3-year time period. From this database, all adults on chronic disease registers for the following six conditions were identified: hypertension (HT), diabetes mellitus (DM), coronary heart disease (CHD), chronic obstructive pulmonary disease (COPD), chronic heart failure (CHF) and chronic kidney disease (CKD).

Multimorbidity definitions

While multimorbidity could be characterised for the study as any number or multiple combinations, we selected 'pairs' as the basic measure of investigating multimorbidity. The 'pairs' measure provides the basis for clinically intuitive understanding of how two chronic disease pathways might combine together, but with six studies of chronic diseases chosen, the potential number of pairs could be 6×6=36. Therefore, six example pairs were chosen to represent the range of chronic diseases onsets from midlife to old age and included: (1) DM and HT; (2) DM and CHD; (3) DM and CKD; (4) COPD and CHD; (5) COPD and CHF and (6) CHF and CKD. These multimorbid pairs were then compared with their respective 'index' conditions, for example,

Table 1 Study groups

Annotation	Study groups
HT+ DM−	Hypertension *without* diabetes mellitus
DM+ HT−	Diabetes mellitus *without* hypertension
HT and DM	Multimorbidity of hypertension *and* diabetes mellitus
DM+ CHD−	Diabetes mellitus *without* coronary heart disease
CHD+ DM−	Coronary heart disease *without* diabetes mellitus
DM and CHD	Multimorbidity of diabetes mellitus *and* coronary heart disease
DM+ CKD−	Diabetes mellitus *without* chronic kidney disease
CKD+ DM−	Chronic kidney disease *without* diabetes mellitus
DM and CKD	Multimorbidity of diabetes mellitus *and* chronic kidney disease
COPD+ CHD−	Chronic obstructive pulmonary disease *without* coronary heart disease
CHD+ COPD−	Coronary heart disease *without* chronic obstructive pulmonary disease
COPD and CHD	Multimorbidity of chronic obstructive pulmonary disease *and* coronary heart disease
COPD+ CHF−	Chronic obstructive pulmonary disease *without* chronic heart failure
CHF+ COPD−	Chronic heart failure *without* chronic obstructive pulmonary disease
CHF and COPD	Multimorbidity of chronic heart failure *and* chronic obstructive pulmonary disease
CHF+ CKD−	Chronic heart failure *without* chronic kidney disease
CKD+ CHF−	Chronic kidney disease *without* chronic heart failure
CKD and CHF	Multimorbidity of chronic kidney disease *and* chronic heart failure

CHD,coronary heart disease; CHF, chronicheart failure; CKD,chronic kidney disease; COPD,chronic obstructive pulmonary disease; DM, diabetes mellitus; HT,hypertension.

HT and DM multimorbidity was compared with the group with HT without DM (expressed as HT+ DM−) and DM without HT (DM+ HT−). Each multimorbid group and their respective 'index' conditions represent a within group (see table 1 for annotation of all study defined groups) and separate clinical hypothesis of the association between multimorbidity and healthcare outcomes. While this 'multimorbid pairs' approach means that there might be overlap between different pair groups, each study group had been selected by common conditions of interest, and not in relation to other multimorbidity that might be present or absent.

In addition to age and gender data available from the general practice records, the Index of Multiple Deprivation (IMD) was used as a measure of socioeconomic status.

IMD is a measure of multiple deprivation at the small area level.[15] Based on the Census data, the score combines a number of indicators, including economic, social and housing issues, into a single deprivation score for each small area in England.

Healthcare transitions data: A&E episodes and hospital admissions

Using the unique National Health Service (NHS) Number allocated to an individual patient, a dataset was created linking their clinical data from general practice to any other information such as A&E attendance and hospital admissions (planned and unplanned) for the time period 1 January 2007 to 31 December 2009. The total number of attendances in the study time period for each A&E type including minor injury units and walk-in centres were included. While there are a number of hospital providers within the region, the single major provider of emergency and acute hospital services for the city is the University Hospital of North Staffordshire NHS Trust. Hospital admissions were based on Hospital Episode Statistics, which contain records for all NHS patients admitted to any English hospitals in each financial year. These A&E and hospital data are the means by which Primary Care (PCT) Commissioners arrange payment from the purchaser to the acute hospital Trust provider.[16] Linking these clinical databases makes it possible to track the healthcare patterns of individual patients. We therefore used these data to establish the natural history of patients with multimorbidity and transitions across the A&E and hospital interfaces.

Healthcare transitions cost

For each transition activity, the allocated Healthcare Resource Group (HRG) was used as a measure of cost for an A&E episode or a hospital admission in the 3-year time period. An HRG is a group of clinically similar treatments and care that requires similar levels of healthcare resource. It allows commissioners to understand their activity in terms of the types of patients they care for and the treatments they undertake.[17 18] HRGs are currently used as a means of determining the costs for individual patients in each financial year, depending on their healthcare use. From the individual-level HRG cost data for A&E episodes or hospital admission, data were aggregated to the population-level costs for the specified multimorbidity groups for the whole of the 3-year time period. Individual-level data were anonymised by the Public Health Intelligence Team and subsequently linked for analyses using a study identifier by the project team, and provision of the anonymous data was made under existing service agreements.

Analyses

The multimorbidity populations are described by age bands (40–49, 50–59, 60–69, 70–79, 80–89, 90 years and over), gender and deprivation. The IMD score for the study population was summarised into quartiles ranging from quartiles 1 (least deprived) to 4 (most deprived). The sociodemographic prevalence pattern for the study multimorbidity pairs and respective index conditions, including the population without index condition, was also estimated and information is given in online supplementary tables S1–S3.

Interface transitions for the six multimorbid groups and their respective index conditions were defined as follows. A&E transitions were first summarised as at least one episode in any one of the 3 years, and so does not include multiple episodes within the same year. A similar approach was used for summarising the hospital admissions. χ^2 Tests were used to assess trends in the association between study defined groups and recurrent A&E episodes and hospital admissions (defined as at least one in each of the 3 years). These data are then presented as counts measured from 0 (no episodes or admissions), 1 (one episode in any one of the 3 years), 2 (two episodes in any two of the 3 years) and 3 (at least one episode in all 3 years). Analysis of variance and analysis of covariance with actual age, gender and IMD as covariates were used to estimate the significance of mean differences of the number of A&E episodes, hospital admissions and costs within each of the multimorbid groups, comparing the pairs of diseases to their respective index diseases.

Total costs for the study time period were estimated for each individual patient who had any A&E episode or hospital admissions, and here the total costs relate to all A&E episodes and hospital admissions over the 3-year time period. Using linear regression methods, the difference in total cost per patient over the 3 years for each multimorbid group was compared with the respective index conditions assessed, adjusting for age, gender and deprivation. Within each of the six multimorbid groups, the regression coefficient was tested for significance differences from their respective reference category with cost allocation as zero (0).

RESULTS

From a study population of 60 660 patients aged 40 years and over on specific chronic disease registers in a 3-year time period, there were 9735 patients with HT and DM (16%), 3574 with DM and CHD (6%), 2894 with DM and CKD (5%), 1855 with COPD and CHD (3%), 754 with CHF and COPD (1%) and 1425 with CHF and CKD (2%). The sociodemographic prevalence figures for the multimorbidity pair groups and comparator groups are given in online supplementary tables S1–S3.

Sociodemographic characteristics of multimorbid pairs

Multimorbid pairs, which included DM and HT or CHD, showed age-related differences (table 2). Within the DM and CKD multimorbid group, there was a higher proportion of older patients aged 70 years and over (51%) than within the DM and CHD group or the HT and DM multimorbid group. There were more women (64%) than men within the DM and CKD group, than the other two DM multimorbid groups, but the deprivation distributions were similar. Within the COPD and CHF multimorbid group, there was a higher proportion of older patients aged 70 years and over (75%), compared with COPD and CHD group, but within the COPD and CHD group there were more men (62%) than women. The CHF and CKD multimorbid group had the highest

Table 2 Sociodemographic characteristics of the multimorbid study pairs

Groups	HT and DM N (%) (n=9735)	DM and CHD N (%) (n=3574)	DM and CKD N (%) (n=2894)	CHD and COPD N (%) (n=1855)	CHF and COPD N (%) (n=754)	CHF and CKD N (%) (n=1425)
40–49 years	866 (8.9)	152 (4.2)	48 (1.7)	22 (1.2)	4 (0.5)	6 (0.4)
50–59 years	2043 (21.0)	533 (14.9)	227 (7.8)	179 (9.6)	42 (5.5)	49 (3.4)
60–69 years	2866 (29.4)	1067 (29.8)	645 (22.3)	499 (26.8)	140 (18.6)	177 (12.4)
70–79 years	2686 (27.6)	1219 (34.1)	1200 (41.3)	710 (38.3)	298 (39.3)	488 (34.2)
80–89 years	1152 (11.9)	552 (15.5)	691 (24.0)	409 (22.1)	236 (31.6)	594 (41.9)
90 years and over	122 (1.3)	51 (1.5)	83 (2.9)	36 (2.0)	34 (4.5)	111 (7.7)
Men	5016 (51.5)	2162 (60.4)	1055 (36.4)	1152 (62.1)	427 (56.4)	549 (38.5)
Women	4719 (48.5)	1412 (39.6)	1839 (63.6)	703 (37.9)	327 (43.6)	876 (61.5)
Quartile 1* Least deprived	2044 (21.1)	691 (19.5)	596 (20.7)	249 (13.5)	109 (14.5)	300 (21.1)
Quartile 2	2335 (24.1)	785 (22.1)	652 (22.6)	428 (23.2)	171 (22.8)	340 (23.9)
Quartile 3	2541 (26.2)	934 (26.3)	801 (28.9)	527 (28.5)	205 (27.3)	401 (28.2)
Quartile 4 Most deprived	2768 (28.6)	1142 (32.2)	831 (28.9)	644 (34.8)	265 (35.3)	379 (26.7)

*Deprivation measured using the Index of Multiple Deprivation.
CHD, coronary heart disease; CHF, chronic heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HT, hypertension.

proportion of patients who were aged 80 years and over (50%), and this group had more women than men.

Multimorbidity transitions across the A&E interface

Patients with HT and DM had the highest proportion without an A&E episode in the 3-year time period (63%), whereas patients with CKD and CHF had the lowest proportion without an A&E episode in the 3-year time period (33%; table 3). The same figures for other multimorbid groups were as follows: DM and CHD 52%; DM and CKD 51%; COPD and CHD 44% and CHF and COPD 42%.

The proportion of patients with recurrent A&E episodes (defined as at least one episode in each of the 3 years) for multimorbid groups was as follows: HT and DM 2%, DM and CHD 4%, DM and CKD 3%, COPD and CHD 5%, CHF and COPD 7% and CKD and CHF 6%. These associations and increases across groups were even more evident for patients who had had an A&E episode in any two of the 3 years (table 3).

For all six groups, when multimorbid pairs were compared with their respective index condition, there was an increasing and highly significant trend in the association between multimorbidity and recurrent A&E episodes ($p<0.001$).

Multimorbidity transitions across hospital admission interface

Patients with HT and DM had the highest proportion without a hospital admission in the 3-year time period (49%), but patients with CKD and CHF had the lowest proportion without a hospital admission in the 3-year time period (21%; table 3). The same figures for other multimorbid groups were as follows: DM and CHD 39%; DM and CKD 37%; COPD and CHD 31% and CHF and COPD 28%.

The proportion of patients with recurrent hospital admissions (defined as at least one in each of the 3 years) for multimorbid groups was as follows: HT and DM 6%; DM and CHD 10%; DM and CKD 10%; COPD and CHD 12%; CHF and COPD 13% and CKD and CHF 13%. These associations and increases across groups were even more evident for patients who had had a hospital admission in any two of the 3 years (table 3).

For all six groups, when multimorbid pairs were compared with their respective index conditions, there was an increasing and highly significant trend in the association between multimorbidity and higher hospital admission ($p<0.001$).

Healthcare costs at the A&E transition

Patients with HT and DM had the lowest mean A&E costs in the 3-year time period (total £69), but the highest figure was for patients with CHF and COPD or CKD (around £166; table 4). The same figures for other multimorbid groups were as follows: DM and CHD £104; DM and CKD £105; COPD and CHD £138; and CHF and COPD £164.

Adjusting for age, gender and deprivation still showed that each of the six multimorbid groups had significantly higher A&E costs than their respective index diseases. When associations between multimorbid groups and costs were adjusted, there were two notable groups. The A&E costs were £13 lower for the index CHD group compared with the index COPD group, and £31 lower for the index CKD group than the CHF group (table 3). For all six groups, when multimorbid pairs were compared with their respective index conditions, there was an increasing and highly significant trend in the association between multimorbidity and higher A&E costs ($p<0.001$).

Healthcare costs at the hospital admission transition

Patients with HT and DM had the lowest mean hospital admissions costs in the 3-year time period (total £2289), but patients with CHF and CKD had the highest costs (£5344; table 4). The same figures for the other multimorbid groups were as follows: DM and CHD £3372; DM and CKD £3642; COPD and CHD £3992; and CHF and COPD £4901.

Adjusting for age, gender and deprivation still showed that each of the six multimorbid groups had significantly higher hospital admission costs than their respective index diseases. When associations between multimorbid groups and costs were adjusted, there were two notable groups. The hospital admission costs were £152 lower for the index CHD group compared with the index COPD group, and £629 lower for the index CKD group than the CHF group (table 4). For all six groups, when multimorbid pairs were compared with their respective index conditions, there was an increasing and highly significant trend in the association between multimorbidity and higher hospital admission costs ($p<0.001$).

The six multimorbid groups were selected on the basis of age-related onsets. However, comparing the findings for the six multimorbid pairs, after age adjustment, also showed that these groups can be placed into an order of an increasing association between the 'severity' of multimorbid pairs and the likelihood of A&E episodes and associated costs, or hospital admissions and associated costs over the 3-year time period. The 'severity' of healthcare impact can be ordered as follows: DM and HT ('low severity'), DM and CHD, DM and CKD, COPD and CHD, CHF and COPD, and CHF and CKD ('high severity'; tables 3 and 4).

DISCUSSION

Our large-scale study in a chronic disease population showed that patients with specific multimorbidity pairs had distinct variations in healthcare transitions and in the associated healthcare costs. While age is a specific indicator for the type of multiple chronic disease, adjustment for sociodemographic factors still showed that specific multimorbidity pairs were associated with a higher number of healthcare transitions compared with their

Table 3 Multimorbidity transitions across A&E and hospital admission interface over 3 years

	A&E episodes				Hospital admissions			
Study groups*	0 N (%)	1 N (%)	2 N (%)	3 N (%)	0 N (%)	1 N (%)	2 N (%)	3 N (%)
HT+ DM−	26 019(68.6)	8903 (23.5)	2466 (6.5)	548 (1.4)	21 957 (54.0)	10 443 (27.5)	4223 (11.1)	1313 (3.5)
DM+ HT−	2733 (63.2)	1154 (26.4)	372 (8.4)	96 (2.1)	2343 (54.0)	1192 (27.5)	601 (13.8)	204 (4.7)
HT and DM	6168 (63.4)	2581 (26.5)	776 (8.0)	210 (2.2)	4800 (49.3)	2888 (29.7)	1456 (15.0)	591 (6.1)
DM+ CHD−	7048 (67.1)	2580 (24.6)	703 (6.7)	170 (1.6)	5766 (54.9)	2993 (28.2)	1403 (12.7)	490 (4.2)
CHD+ DM−	6223 (57.6)	3175 (29.4)	1133 (10.5)	276 (2.6)	4842 (44.8)	3482 (32.2)	1813 (16.8)	670 (6.2)
DM and CHD	1863 (52.1)	1145 (32.0)	436 (12.2)	130 (3.6)	1377 (38.5)	1123 (31.4)	721 (20.2)	353 (9.9)
DM+ CKD−	7440 (66.5)	2761 (24.7)	775 (6.9)	205 (1.8)	6083 (54.4)	3142 (28.1)	1438 (12.9)	518 (4.6)
CKD+ DM−	5137 (57.3)	2733 (30.5)	893 (10.0)	195 (2.2)	3923 (43.8)	3056 (34.1)	1502 (16.8)	477 (5.3)
DM and CKD	1471 (50.8)	964 (33.3)	364 (12.6)	95 (3.3)	1060 (36.6)	938 (32.4)	619 (21.4)	277 (9.6)
COPD+ CHD−	3013 (56.8)	1568 (29.6)	546 (10.3)	177 (3.3)	2443 (46.1)	1665 (31.4)	843 (15.9)	353 (6.7)
CHD+ COPD−	7267 (58.0)	3689 (29.5)	1261 (10.1)	309 (2.5)	5641 (45.0)	3973 (31.7)	2108 (16.8)	804 (6.4)
COPD and CHD	819 (44.2)	631 (34.0)	308 (16.6)	97 (5.2)	578 (31.2)	632 (34.1)	426 (23.0)	219 (11.8)
COPD+ CHF−	3519 (54.9)	1940 (30.3)	723 (11.3)	223 (3.5)	2810 (43.9)	2018 (31.5)	1102 (17.2)	475 (7.4)
CHF+ COPD−	1346 (46.7)	990 (34.3)	440 (15.3)	108 (3.7)	978 (33.9)	996 (34.5)	645 (22.4)	265 (9.2)
CHF and COPD	313 (41.5)	259 (34.4)	131 (17.4)	51 (6.8)	211 (28.0)	279 (37.0)	167 (22.1)	97 (12.9)
CHF+ CKD−	1173 (53.0)	665 (30.0)	295 (13.3)	80 (3.6)	884 (39.9)	737 (33.3)	414 (18.7)	178 (8.0)
CKD+ CHF−	6122 (58.7)	3113 (29.9)	981 (9.4)	211 (2.0)	4678 (44.9)	3456 (33.1)	1723 (16.5)	570 (5.5)
CKD and CHF	481 (33.4)	595 (41.3)	284 (19.7)	80 (5.6)	305 (21.4)	538 (37.8)	398 (27.9)	184 (12.9)

*Minus sign indicates absence of disease and positive sign indicates presence.
A&E, accident and emergency; CHD, coronary heart disease; CHF, chronic heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HT, hypertension.

Table 4 Multimorbidity transitions across A&E episodes and hospital admissions and associated costs over 3 years

Study groups	3-year AE £ costs Mean (SD)	Adjusted-regression* estimates £ (SE)	p Value	3-year IP £ costs Mean (SD)	Adjusted-regression* estimates £ (SE)	p Value
HT+ DM−	55 (132)	0		1647 (4085)	0	
DM+ HT−	69 (162)	20 (2)	<0.001	2061 (4490)	595 (68)	<0.001
HT and DM	69 (152)	14 (2)	<0.001	2289 (4585)	607 (48)	<0.001
DM+ CHD−	57 (124)	0		1825 (3977)	0	
CHD+ DM−	84 (175)	22 (2)	<0.001	2512 (5825)	431 (73)	<0.001
DM and CHD	104 (219)	42 (3)	<0.001	3372 (5789)	1270 (101)	<0.001
DM+ CKD−	60 (143)	0		1850 (3996)	0	
CKD+ DM−	80 (144)	4 (2)	0.14	2559 (4380)	403 (73)	<0.001
DM and CKD	105 (190)	30 (3)	<0.001	3642 (6063)	1480 (97)	<0.001
COPD+ CHD−	96 (214)	0		2642 (4814)	0	
CHD+ COPD−	81 (180)	−13 (4)	<0.001	2537 (5812)	−152 (92)	0.097
COPD and CHD	138 (219)	40 (5)	<0.001	3992 (5775)	1158 (151)	<0.001
COPD+ CHF−	100 (211)	0		2769 (4925)	0	
CHF+ COPD−	120 (192)	17 (5)	<0.001	3877 (5732)	904 (125)	<0.001
CHF and COPD	166 (242)	64 (8)	<0.001	4901 (6199)	1954 (206)	<0.001
CHF+ CKD−	108 (176)	0		3282 (4880)	0	
CKD+ CHF−	75 (139)	−31 (4)	<0.001	2477 (4404)	−629 (114)	<0.001
CKD and CHF	164 (238)	52 (5)	<0.001	5344 (6907)	2116 (163)	<0.001

*Adjusted for age, gender and deprivation as measured by the Index of Multiple deprivation.
A&E, accident and emergency; CHD, coronary heart disease; CHF, chronic heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; HT, hypertension.

respective index groups. Furthermore, these multimorbidity associations suggest that they can be ordered into a 'severity of healthcare impact', after adjusting for age. In this spectrum, a multimorbidity such as HT and diabetes represents one end of the healthcare cost spectrum, and chronic heart failure and CKD represent the higher and more costly end of healthcare impact.

The implications of this multimorbidity study covering a 3-year time period relate to the number and costs of transitions. The study shows that patients with specific multimorbidity have a higher number of annual A&E episodes or hospital admissions and costs, which means that this provides a potential mechanism for targeting patients for intervention across the healthcare interfaces. Since this information could potentially be linked across the interface, it also provides the basis for intervention once initial transitions have occurred to prevent future unnecessary transitions from general practice to A&E or hospital admission.

The study was based on large-scale data available from 53 general practices in one of the most deprived regions in England and over a long-term time period of 3 years. The current national quality improvement approaches have been based on establishing chronic disease registers in clinical practice and aim at improving care for the individual patient.[12 19] However, such registers also provide the basis for defining population-level impacts and for providing the integration between public health prevention (general practice or local area) and individual-level care. The definition of multimorbidity, focusing on 'pairs', also means that it allows easier interpretation of the current individual pathways of care and begins to provide insight into how these might be integrated. For example, HT, diabetes and CHD are often jointly managed in general practice, but in healthcare transitions, specialist care could be delivered by nephrology (HT), diabetes or cardiology. However, in severe chronic disease states, such as COPD, CHF and CKD, which are often jointly managed between general practice and hospital-based care, such a 'multimorbidity pair' approach allows for the integration of care for high-cost patients who may be cared for by several healthcare teams in different individual care pathways.

While this was a large-scale study, the cross-sectional findings relate to one region of England. The patterns of transitions may differ in other regions, especially as services moved to different integrated models, but the relative associations for multimorbid groups compared with the index groups provide the best available estimates on the impact on transitions and costs. These cost estimations and relative are conservative as the reference comparison groups had one of the two multimorbid conditions, whereas a non-index reference group without either pair condition would have magnified the relative cost differences. While new integrated models of care are developing,[20] such care will still need to differentiate between the acute health needs of the patient with a chronic disease, addressed by specialist intervention, and the chronic health needs and monitoring that will be addressed by general practice and community teams. The study definitions also focused on pairs of conditions but all groups were not exclusive, and there was some overlap. For example, diabetes was paired with HT, CHD and CKD, which indicates an overlap, but

these results showed that different pairs with the same index condition (eg, diabetes) have distinct associations with healthcare transitions and costs.

The chronic disease registers from general practice were part of the local and national initiatives, and such data are now used widely in performance and payment reporting, and healthcare studies.[19] The healthcare transition data are also part of national performance and payment reporting, and have also been used in healthcare studies. The recording of these transition episodes (A&E or hospital admission) will be accurate as the healthcare costs are based on the HRG allocated to each individual patient, which is part of the cost transaction process between the healthcare commissioner (PCT) and the provider (hospital). Furthermore, the transitions data and cost data are part of the national validation processes.[16 21] In this study, the primary objective was to test the clinical hypothesis that different multimorbidity pairs showed variations in overall healthcare transitions, and therefore it does not include the attempt to characterise the precise nature of each transition episode. The estimated costs for these patient populations are also an underestimate since they do not include ongoing healthcare costs in general practice and community care.

Previously, there have been few studies on multimorbidity and costs in specific settings,[22 23] but there is a lack of healthcare transitions data, and the hypothesis that a study of specific 'disease pairs' may provide insight into healthcare presentation and costs has not been previously tested. Much of the current multimorbidity research has focused on the 'burden' as exemplified by the number of conditions that patients experience, but the key limitation with the 'counting' approach is the lack of differentiation of how it links into the current individual disease-designed pathways. Arguably, it is better to conceptualise this issue into 'which pairs' and link it practically to the individual disease pathways, which have been devised in terms of the chronic disease model of care.[24] The notion of chronic disease and depression has notably been well constructed in the psychiatric field.[25] This 'disease pair' approach provides a simple and clinically intuitively approach that can be readily used in actual clinical practice, as well as a means by which local policy decisions can incorporate estimated costs for healthcare transitions.

This cross-sectional study provides the basis for the innovative linking of data and understanding the healthcare 'journey' for the patient with different chronic diseases. Further studies would address issues such as multiple healthcare transitions, combining different interfaces (eg, identifying patients who attend A&E regularly and are admitted regularly) and the underlying and precise clinical reasons for the healthcare costs. For example, healthcare transitions may cover community care, and wider transitions could include social care. The associations shown in this study also need to be complemented by the temporal investigation between chronic disease pairs and subsequent impact on the time between healthcare transitions.

In conclusion, our study showed that specific multimorbid pairs compared with their index morbidity indicated the level of transitions across healthcare interfaces and the associated total healthcare costs. Identification of the multimorbidity type and linkage of information across interfaces provides opportunities for targeted intervention and delivery of cost-effective integrated care.

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