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Association between Johns Hopkins Adjusted Clinical Groups risk scores and self-reported outcome measures: an observational study among individuals with complex or long-term conditions in Norway

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ABSTRACT

Objective Investigate the association between Johns Hopkins Adjusted Clinical Groups (ACG) risk scores and low scores in self-reported outcome measures (SROMs) among individuals with complex or long-term conditions.

Design Longitudinal study using five ACG risk scores based on diagnoses from general practitioner (GP) visits in 1 year and responses to a survey including three SROMs 4 months later.

Setting Four adjacent municipalities in Central Norway.

Participants Non-institutionalised individuals ≥18 years with ≥1 diagnosis code indicating a complex or long-term condition, ≥1 visit to a GP, and who participated in the survey (n=2944).

Measures Dependent variables were low scores in the three SROMs (threshold for being defined as a low score in parentheses): Patient Activation Measure (level 1–2), EQ-5D (<0.4) or self-rated health ('Poor'). Independent variables were five ACG variables.

Results The individuals with the lowest scores in the three SROMs were mostly three separate groups. The lowest Patient Activation Measure scores were associated with high scores in the ACG variables unscaled total cost predicted risk (adjusted odds ratio (adjOR) 1.80) and positive frailty flag (adjOR 1.76). The lowest EQ-5D scores were associated with high scores in the ACG variables unscaled concurrent risk (adjOR 1.60) and probability persistent high user scores (adjOR 2.83). The lowest self-rated health scores were associated with high scores in the ACG variable unscaled concurrent risk scores (adjOR 1.77), unscaled total cost predicted risk scores (adjOR 2.14) and receiving a positive frailty flag (adjOR 1.82).

Conclusions There were associations between ACG risk scores and subsequent low SROM scores. This suggests a potential to use diagnosis-based risk stratification systems as a proxy for SROMs to identify individuals with complex or long-term conditions for person-centred healthcare intervention.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study applies high-quality and comprehensive registry data and validated self-reported outcome measures.
⇒ The application of the recognised and validated Adjusted Clinical Groups system strengthens the study's relevance and applicability.
⇒ The study investigated the association between one common risk stratification system and three widely applied self-reported outcome measures, and the results can thus not necessarily be generalised to other measures.

INTRODUCTION

Managing complex or long-term conditions requires person-centred and individually oriented care.[1] Despite increasing attention, healthcare services still struggle to provide high-quality healthcare to individuals with the most complex healthcare needs.[2 3] While developing interventions to effectively improve chronic care management is an important step, it is equally important to identify those most likely to benefit from such interventions.[4] This identification process is typically conducted within the domain of population health management, which aims to enhance population health and quality of care while restraining costs.[5]

A common strategy for achieving this goal is the utilisation of risk stratification tools based on accessible administrative healthcare information such as diagnosis codes. These tools enable the stratification of the population according to their risk of experiencing adverse outcomes.[6] One widely recognised risk stratification software frequently cited in the research literature is the Johns Hopkins

Adjusted Clinical Groups (ACGs) system.[7] This system categorises the population into groups with similar expected resource requirements based on a minimum input data requirement of age, sex and registered diagnoses over a specified time period.

Another approach for the identification of individuals with the most complex healthcare needs involves the use of self-reported outcome measures (SROMs).[8] SROMs can be used as screening tools that give insight into each individual's subjective perception of their quality of life, function and symptom burden.[8] Thus, they can assist in identifying individuals with low SROM scores that are likely to need person-centred and individually oriented care. However, the widespread implementation of SROMs in routine care remains limited, thereby restricting their potential as population-level screening tools.[8 9]

An important question thus arises: Can risk stratification based on accessible administrative healthcare data at the population level serve as proxies for SROMs to screen for specific groups likely to need person-centred and individually oriented care? This would be the case if there were an association between diagnosis-based risk scores and low SROM scores. However, to the best of our knowledge, no studies have investigated the associations between risk scores obtained from common risk stratification systems, such as the ACG system, and low SROM scores.

Therefore, the objective of this study was to investigate the association between Johns Hopkins ACG risk scores and low scores in SROMs among individuals with complex or long-term conditions.

MATERIALS AND METHODS

Study design

This was a health registry-based and survey-based longitudinal study among individuals with long-term or complex health conditions who had visited a general practitioner (GP) in 2013 and participated in the survey. Strengthening the Reporting of Observational Studies in Epidemiology guideline was used to guide the presentation.

Setting

The study utilised data from a larger project that linked healthcare registry data for all adult residents in four municipalities in Central Norway who had visited a somatic healthcare service in 2012–2013 (n=168 973) and a questionnaire-based survey in a random sample of 12 502 individuals with complex or long-term health conditions in April 2014.

Participants

The study included all non-institutionalised individuals ≥18 years residing in the four included municipalities who were registered with a visit to a GP in 2013, for which the GP claimed reimbursement, and who responded to the survey. To be eligible for the survey, individuals had to be registered with minimum one diagnosis code from a GP or hospital contact indicating the presence of a complex or long-term condition during the period of 2012–2013. This selection was based on 162 International Classification of Primary Care, 2nd edition (ICPC-2) codes, and a conversion to the corresponding International Classification of Diseases, 10th edition (ICD-10) codes, representing a conservative assessment of codes used in prior studies.[10–13] Individuals with a diagnosis of paranoia, psychosis or schizophrenia were excluded from the study.

Variables

Dependent variables

Three different SROMs, which assesses patient activation, health-related quality of life (HRQoL) and self-rated health were applied due to their relevance at both individual and population levels,[14–16] their association with health outcomes[16 17] and their ability to measure a potential or need for healthcare intervention.[9]

Patient activation concerns to which extent an individual has the belief, knowledge and skills required to effectively manage a chronic illness.[14] The validated Norwegian version[18] of the 13-item Patient Activation Measure (PAM)[14] was used. Each of the 13 questions offers four response options, and 'Not applicable'. The total score is transformed to a scale ranging from 0 to 100 (higher score indicates greater patient activation). These scores can be categorised into four levels.[14 17]

HRQoL concerns the impact of health status on the individual's ability to lead a fulfilling life and was measured using the EuroQol five-dimension instrument with three response options for each question (EQ-5D-3L).[15] The five dimensions are mobility, self-care, usual activities, pain/discomfort and anxiety/depression. The Danish value set was applied. The scale is a range where 1 represents full health and 0 implies a health state equal to being dead.

Self-rated health concerns the subjective health status based on biological, psychological and cultural aspects[16] and was measured by the question 'In general, would you say your health is:'. The answering option was a 5-point Likert scale ranging from 'Excellent' to 'Poor'.

Independent variables

The ACG risk scores were calculated using V.11.0 of the Johns Hopkins ACG System software with standard American weights. The input data consisted of age, sex and ICPC-2 diagnoses registered by a GP in 2013. Nine ACG risk variables commonly used in previous studies[19–21] were applied. The descriptions of each variable found below are copied from the ACG system V.11.0 Installation and Usage Guide,[22] and is provided in table format in online supplemental table S1.

Several variables concern concurrent risk. On an individual concurrent level, the unscaled concurrent risk variable is a concurrent total cost risk for each individual for the observation period. Based on a regression model against a reference population (with a mean of 1.0), the predicted value is expressed as a relative weight. The unscaled ACG concurrent risk variable is an estimate of

concurrent resource use associated with a given ACG based on a reference database and expressed as a relative value. Each individual is assigned a weight based on their ACG code. On a more aggregated level, the resource utilisation band variable is an aggregation of ACGs based on estimates of concurrent resources that are used to provide a way of separating the population into broad comorbidity groupings from 0 to 5.

For estimates of future resource utilisation, the unscaled total cost predicted risk variable represents estimated total costs (including pharmacy costs) for each individual for the year following the observation period. Based on a reference database (with a mean of 1.0), the predicted value is expressed as a relative weight. The probability persistent high user variable represents the probability that this patient will be in the top 20% of users in the population for four consecutive half-year periods.

Three of the variables are condition counts. The major ADG count is the number of major Adjusted Diagnosis Groups (ADGs) assigned to this patient. A major ADG is an ADG found to have a significant impact on concurrent or future resource consumption. The chronic condition count variable is a count of expanded diagnosis clusters containing trigger diagnoses indicating a chronic condition with significant expected duration and resource requirements. The variable named diagnoses used is a count of the diagnoses that contributed to the morbidity assessment.

As frailty is a clinical feature of special relevance, the frailty flag variables is a flag for any one of the diagnostic clusters that represent discrete conditions consistent with frailty (eg, malnutrition, dementia, incontinence, difficulty in walking).

Sociodemographic variables included age and sex, level of education (categorised into primary, secondary or higher), main activity (currently working, retirement age, social welfare recipient, student or other), family income (below 250 000 NOK, 250 000–500 000 NOK, 500 000–750 000 NOK, 750 000–1 million NOK or above 1 million NOK), and living situation (alone or with others).

Healthcare utilisation variables

Healthcare utilisation variables included the number of GP visits in the past year, having had minimum one inpatient stay at the hospital in the past year (yes or no), having made minimum one outpatient visit to the hospital in the past year (yes or no), receiving municipal home or social care in the past year (yes or no) and receiving municipal nursing care in the past year (yes or no).

Data sources

The data sources were healthcare registry data on the utilisation of GP, hospital and municipal services and the survey that included the three SROMs.

Registry data were collected from three sources. The Norwegian Registry for Reimbursement Claims, administered by the Norwegian Health Economics Administration, provided data on all GP visits in the study period and their associated diagnosis codes. The reimbursement claim from one GP consultation is required to contain minimum one diagnosis code registered as an ICPC-2 code. The included municipalities provided information on which individuals received which type of municipal services. The local hospital provided data on utilisation of their services.

The survey provided information on sociodemographic variables and SROMs. Participants could submit responses by mail or the internet. The invitation declared that returning the survey was considered as providing consent to participate.

Variable handling

Some adjustments were made in the categorisation of the variables for the descriptive, bivariable and multivariable analyses, respectively. This was done to give a higher level of detail in descriptive and bivariable analysis, while having sufficiently large groups for multivariable analyses.

The PAM variable was categorised into four levels as per the developers' categorisation.[18 21] Low PAM scores were defined as having a score ≤55.1, which equals the lowest two levels of activation (Level 1 and 2). The EQ-5D variable was categorised into 0.2-pint ranges (−1 to −0.01, 0 to 0.19, 0.2 to 0.39, 0.4 to 0.59, 0.6 to 0.79, 0.8 to 1). Low EQ-5D was defined as having a score <0.4. The SRH variable was used without additional categorisation. Low SR was defined as answering the lowest category 'Poor'.

The continuous ACG risk scores were divided into ranges (0–0.49, 0.5–0.99, 1–1.99, 2–3.99, ≥4) in accordance with a previous study.[23] In the multivariable analyses the resource utilisation bands were reduced from five to four categories (1, 2, 3, ≥4), and the continuous ACG risk scores were collapsed from five to four categories (0–0.49, 0.5–0.99, 1–1.99, ≥2).

Several ACG variables showed strong correlation, and including all variables resulted in instability and fluctuating coefficients. A conservative approach was therefore adopted, where variables with correlation coefficients exceeding 0.51 were identified and the variables most frequently reported in the research literature were retained. This resulted in five variables being included in the bivariable analysis: resource utilisation band, unscaled concurrent risk, unscaled total cost predicted risk, probability persistent high user and frailty flag. Although not strongly correlated, including the probability persistent high user variable in the analysis of SRH made the OR of other independent variables to have different directions (eg, from above 1 to below 1) in the bivariable and multivariable analysis. This variable was therefore excluded from the SRH model.

Age and sex were omitted as independent variables as they were used as input variables in ACG analyses.

Statistical methods

All analyses were performed using Stata V.16.0 MP. Characteristics of respondents, non-respondents and participants are presented using descriptive statistics.

Responder analyses were performed using χ^2 test for categorical variables, two-group proportion test for proportions and t-test for continuous variables.

Bivariable analyses were performed using χ^2 test for categorical variables and t-test for continuous variables.

Multivariable analyses were three logistic regression analyses, one with each of the SROMs as the dependent variable and five ACG variables as independent variables in all models. Correlation was evaluated using Pearson and Spearman correlation coefficients. The Hosmer-Lemeshow test indicated good fit (p values 0.22–0.98).

Patient and public involvement

Patients or the public were not involved in the planning or conduction of the study.

Supplemental analyses: hospital sample

Visits to and diagnosis codes registered by GPs were considered the best inclusion criteria and data material for answering the objective of the study. However, as previous research has found that different persons are identified when using data from GPs and hospitals, respectively,[23] a separate supplementary analysis using hospital data was conducted and can be found as supplemental material. This analysis was conducted in the same manner as for the main analysis described above. The only difference was that the ACG analysis was performed using ICD-10 codes from the hospital, and the sample was restricted to those who had contact with a somatic hospital healthcare service in 2013. The samples of the main and supplemental analyses are later referred to as the GP sample and the hospital sample respectively.

RESULTS

Among the 85 580 non-institutionalised individuals with minimum one diagnosis code indicating a chronic or long-term condition between 2012 and 2013, and who visited a GP in 2013, 11 347 were among the randomly selected 12 502 individuals who were invited to participate in the survey with the three SROMs. Of this group, 2944 (25.9%) answered (online supplemental figure A1).

Responder analysis and sample characteristics

The characteristics of respondents and non-respondents were generally similar. However, non-respondents tended to be younger, and a larger proportion received municipal support (table 1). There were no differences in sex or

Table 1 Characteristics of respondents (n=2944) and non-respondents (n=8403)

Characteristic	Respondents n=2944	Non-respondents n=8403	P value
Age group (years)			<0.001
8–44	704 (23.9%)	3106 (37.0%)	
45–64	1010 (34.3%)	2494 (29.7%)	
65–74	673 (22.9%)	1186 (14.1%)	
75–84	401 (13.6%)	988 (11.8%)	
85+ years	155 (5.3%)	629 (7.5%)	
Sex			0.347
Male	1252 (42.5%)	3490 (41.5%)	
Female	1692 (57.5%)	4913 (58.5%)	
Number of ICPC-2 chapters with a registered diagnosis			0.090
1	534 (18.1%)	1610 (19.2%)	
2	752 (25.5%)	2065 (24.6%)	
3	677 (23.0%)	1874 (22.3%)	
4	517 (17.6%)	1413 (16.8%)	
5	251 (8.5%)	816 (9.7%)	
6	141 (4.8%)	354 (4.2%)	
7–10	72 (2.4%)	271 (3.2%)	
Healthcare utilisation past year			
Number of GP visits (mean)	10.4	11.0	0.013
≥1 inpatient hospital stay	632 (21.5%)	1638 (19.5%)	<0.021
≥1 outpatient hospital visit	681 (23.1%)	1876 (22.3%)	0.367
Received municipal home care (social care)	185 (6.3%)	918 (10.9%)	<0.001
Received municipal nursing care	212 (7.2%)	1174 (14.0%)	<0.001

ICPC-2, International Classification of Primary Care, 2nd edition.

the number of unique ICPC-2 chapters. Non-respondents had a slightly higher mean number of GP visits, although the median was equal in both groups (eight visits). A slightly higher proportion of respondents had an inpatient hospital visit in the past year, while a lower proportion received home or nursing care, compared with non-respondents.

The mean age of the participants was 58.1 (median 60, range 18–97), and 6 out of 10 were female (table 1). Approximately half reported to have completed higher education, and the majority were currently employed (table 2). A smaller proportion had reached retirement age, and about 1 out of 10 received other social welfare benefits. Approximately half reported an annual income exceeding 500 000 NOK (equivalent to 61 300 € in June 2014). Slightly less than half reported living alone.

The ACG analysis showed that 5.7% of the sample were in resource utilisation band 4 or 5 (table 2), 5.5% had an unscaled ACG concurrent risk score above 2, while 11.4% had an unscaled concurrent risk score above 2. Nearly 3 in 10 scored above 2 in the unscaled total cost predicted risk variable, 5.8% received a score of minimum 10% for the likelihood of being a persistent high user in the subsequent 2 years, and 3.0% received a positive frailty flag. The participants had a mean of 3.8 registered diagnoses in 2013, with a mean of slightly less than one chronic condition. They also had a mean of 0.5 major ADGs.

Most participants obtained high scores in all PAM, EQ-5D and self-rated health variables (table 2). The mean PAM score was 71.6 (SD 18.2, median 72.5), and more than half were in PAM level 4 (the level indicating highest activation). The EQ-5D values had a mean of 0.77 (SD 0.21, median 0.82). The mean SRH value of 3.0 corresponded to the rating 'Good', and a majority of nearly 6 out of 10 reported good, very good or excellent overall health.

Individuals with low self-reported scores

The proportion of the total sample who were categorised as having low scores in each SROM was 8.8% for PAM, 8.3% for EQ-5D (0.6% obtained a negative score), and 7.2% for self-rated health. A total of 612 (20.8%) participants scored low in minimum one of the three SROMs (figure 1). Of these, a majority (71%) scored low in only one of the measures, while 6% scored low in all three measures. Consequently, the three measures primarily identify three separate groups of individuals.

The 612 participants with minimum one low SROM score had a mean age of 62.2 (median 66, range 18–96), and nearly 6 in 10 were female. Their mean number of GP visits in the previous year was nearly 16 (median 14 visits). Four in 10 had been hospitalised and 3 in 10 had minimum one outpatient visit to the hospital in the previous year. Social or nursing care was received by 16% and 17%, respectively. One-third reported to having completed higher education, and a similar proportion reported an annual income exceeding 500 000 NOK (equivalent to 61 300€ in June 2014) (table 2). Nearly

Table 2 Baseline characteristics of participants (n=2944) and individuals with a low score in ≥1 SROM (n=612)

Characteristics	Participants n (%)*	≥1 Low SROM score† n (%)*
Sociodemographic data		
Level of education		
Primary	491 (17.6)	158 (27.7)
Secondary	950 (34.1)	218 (38.2)
Higher	1341 (48.2)	195 (34.1)
Main daily activity		
Currently working	1244 (44.3)	159 (27.7)
Retirement age	977 (35.0)	230 (40.1)
Social welfare recipient	356 (12.7)	129 (22.5)
Student	112 (2.1)	24 (4.2)
Other (homemaker, job seeker)	107 (3.8)	32 (5.6)
Annual gross income‡		
Below 250 000	382 (14.0)	150 (26.8)
250 000–500 000	888 (32.5)	214 (38.2)
500 000–750 000	637 (23.3)	106 (18.9)
750 000–1 million	462 (16.9)	59 (10.5)
Above 1 million	365 (13.3)	31 (5.5)
Lives alone	771 (44.3)	211 (51.6)
ACG variables		
Resource utilisation band		
1	202 (6.9)	34 (5.6)
2	743 (25.2)	117 (19.1)
3	1829 (62.1)	411 (67.2)
4	160 (5.4)	46 (7.5)
5	10 (0.3)	4 (0.6)
Unscaled ACG concurrent risk		
0–0.49	1103 (37.5)	189 (30.9)
0.5–0.99	1141 (38.8)	228 (37.2)
1–1.99	536 (18.2)	147 (24.0)
2–3.99	151 (5.1)	44 (7.2)
≥4	13 (0.4)	4 (0.6)
Unscaled concurrent risk		
0–0.49	1583 (53.8)	271 (44.3)
0.5–0.99	544 (18.5)	119 (19.4)
1–1.99	479 (16.3)	122 (19.9)
2–3.99	240 (8.1)	61 (10.0)
≥4	98 (3.3)	39 (6.4)
Unscaled total cost predicted risk		
0–0.49	347 (11.8)	52 (8.5)
0.5–0.99	812 (27.6)	136 (22.2)
1–1.99	1020 (34.6)	199 (32.5)
2–3.99	653 (22.2)	185 (30.3)
≥4	112 (3.8)	40 (6.5)
Probability persistent high user (%)		
0–9	2772 (94.2)	543 (88.7)
10–14	118 (4.0)	47 (7.7)
15–19	36 (1.2)	14 (2.3)
≥20	18 (0.6)	8 (1.3)

Continued

Table 2 Continued

Characteristics	Participants n (%)*	≥1 Low SROM score† n (%)*
Major ADG count (mean)	0.5 (SD: 0.63)	0.6 (SD: 0.70)
Chronic condition count (mean)	0.9 (SD: 0.98)	1.2 (SD: 1.14)
Diagnoses used (mean)	3.8 (SD: 2.39)	4.4 (SD: 2.79)
Frailty flag		
Yes	89 (3.0)	29 (4.7)
SROMs		
Patient Activation Measure§		
Level 1 (0–47.0)	225 (8.8)	225 (37.8)
Level 2 (47.1–55.1)	154 (6.0)	154 (25.9)
Level 3 (55.2–72.4)	755 (29.7)	107 (18.0)
Level 4 (72.5–100)	1410 (55.4)	109 (18.3)
EQ-5D¶		
−1−−0.01	18 (0.6)	18 (3.0)
0–0.19	36 (1.3)	36 (6.1)
0.2–0.39	183 (6.4)	183 (31.0)
0.4–0.59	137 (4.8)	66 (11.2)
0.6–0.79	969 (33.9)	183 (31.0)
0.8–1	1515 (53.0)	104 (17.6)
Self-rated health		
Poor	210 (7.2)	210 (34.8)
Fair	646 (22.2)	208 (34.5)
Good	1118 (38.4)	138 (22.9)
Very good	728 (25.0)	42 (7.0)
Excellent	212 (7.3)	5 (0.8)

*The n for each variable can vary due to some variation in the number that answered each question in the survey.
†An individual was defined as having ≥1 low SROM score if being PAM level 1–2, having an EQ-5D score <0.4 or self-rated health score 'Poor'.
‡1 NOK=0.12€ in June 2014.
§Range 0 to 100. Higher values indicate higher patient activation.
¶Range −1 to 1. Higher values indicate better health-related quality of life.
ADG, Adjusted Diagnosis Group; EQ-5D, EuroQol 5-dimension; SROMs, self-reported outcome measures.

1 in 3 reported currently working, whereas 6 in 10 were retired or received other social welfare. Half reported living alone.

ACG analysis showed that 8.1% of those with low SROM scores were in resource utilisation band 4 or 5 (table 2), 7.8% received an unscaled ACG concurrent risk score above 2, and 16.4% received an unscaled concurrent risk score above 2. Nearly 4 in 10 scored above 2 in the unscaled total cost predicted risk variable, 3.6% had a probability above 10% for becoming persistent high users the following 2 years, and 4.7% were flagged as frail by the ACG system. They had a mean number of 4.4 registered diagnoses, of which 1.2 were considered chronic.

The mean PAM score among those with a low score in minimum one of the SROMs was 52.8 (median 51, range 0–100), the mean EQ-5D score 0.55 (median 0.61, range −0.6 to 1) and the mean value for SRH corresponded to 'Fair'.

Association between ACG risk scores and SROMs

The results from the bivariable analysis are presented in table 3. The factors higher age, higher unscaled concurrent risk, higher unscaled total cost predicted risk, higher probability persistent high user risk and higher number of major ADGs and chronic conditions had a bivariable association with PAM level 1–2. Higher age, being female and an increased score in all ACG variables had a bivariable association with low EQ-5D. All independent variables except sex had a bivariable association with poor self-rated health.

The multivariable logistic regression analysis is shown in table 4. An unscaled total cost predicted risk above two (adjusted odds ratio (adjOR) 1.80) and a positive frailty flag (adjOR 1.76) were associated with low PAM scores (PAM level 1–2).

Probability persistent high user scores above 10% were associated (adjOR 2.83) with the lowest EQ-5D scores (EQ-5D <0.40). This was the highest adjOR found in the analysis. An evident gradient indicated that increasing unscaled concurrent risk scores were also associated with low EQ-5D scores (adjOR 1.60 in the highest score group).

Having twice the average score in the unscaled total cost predicted risk (adjOR 1.77), and unscaled total cost predicted risk (adjOR 2.14) variable, and receiving a positive frailty flag (adjOR 1.82), were associated with low SRH.

Hospital sample

The supplementary analyses of the hospital sample (n=1 921) are presented in online supplemental tables A2–A5 and online supplemental figure A2. The responder analysis (online supplemental table A2) showed similarities between respondents and non-respondents. A total of 428 (22.3%) participants scored low in minimum one of the three SROMs (online supplemental figure A2). Of these, a majority (70.8%) scored low in only one of the measures, while 6.5% scored low in all three measures. Baseline characteristics of participants (online supplemental table A3) showed that the proportion of those with minimum one low SROM score who had completed higher education was lower. A higher proportion received social welfare, had a lower income and lived alone. Their ACG risk scores were generally higher than that for the GP sample and a higher proportion reported low scores in each of the SROMs. Bivariable analyses (online supplemental table A4) showed findings similar to the GP sample. The multivariable analyses showed that unscaled total cost predicted risk above two (adjOR 1.77) and positive frailty flag (adjOR 2.22) were associated with low PAM scores (online supplemental table A5). A positive frailty flag was associated with the lowest EQ-5D scores (adjOR 3.36). Higher unscaled total cost predicted risk (adjOR 3.37) and a positive frailty flag (adjOR 3.12) were associated with the lowest SRH scores.

DISCUSSION

Our study revealed notable associations between several ACG risk scores and low SROM scores. A clear gradient

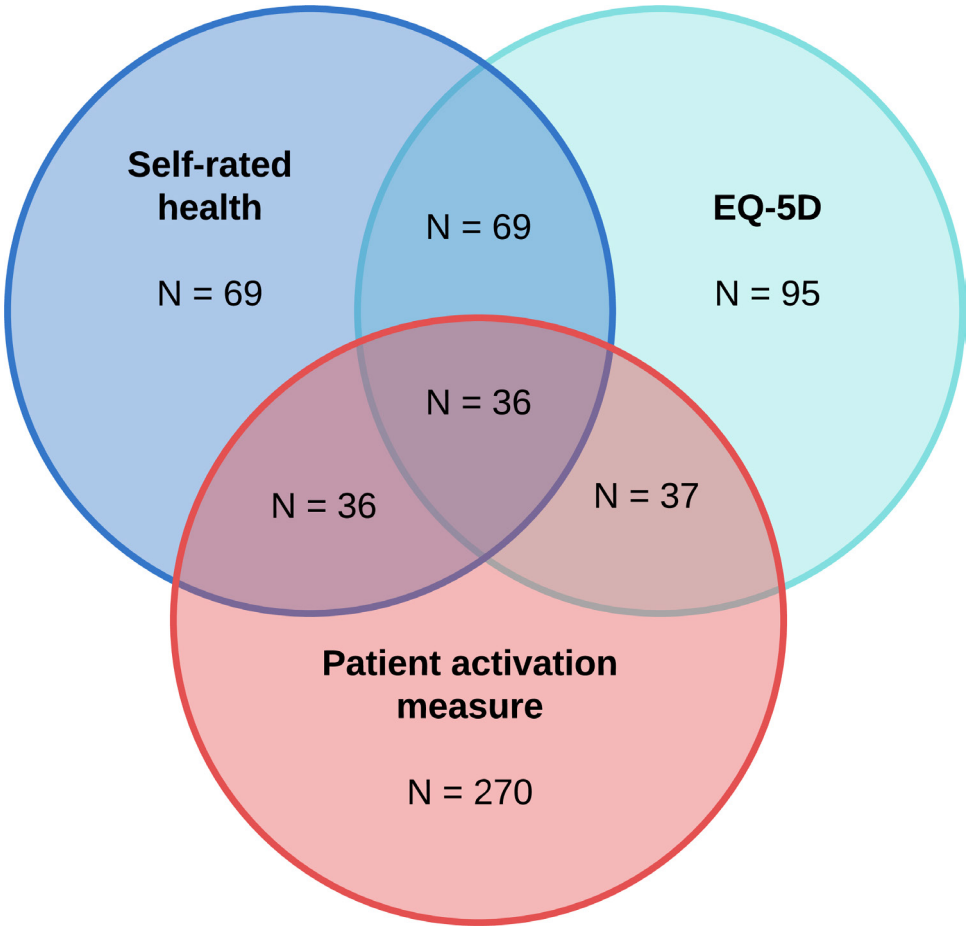

Figure 1 Venn diagram with number of participants with low scores in Patient Activation Measure, EQ-5D and self-rated health (n=612). EQ-5D, EuroQol 5-dimension.

between higher ACG scores and lower SROM scores were evident in the bivariable analysis. In multivariable analysis, a score twice the mean ACG risk score in the population was associated with low SROM scores. More specifically, anticipated high resource utilisation in the following year (indicated by the 'total cost predicted risk' variable) or a positive frailty flag by the ACG system were associated with low patient activation. High resource utilisation in the past year ('unscaled concurrent risk') and the subsequent 2 years ('probability persistent high user') were associated with low HRQoL and low self-rated health scores. Additionally, a positive frailty flag was associated with low self-rated health scores.

In the hospital sample, similar associations were found between ACG risk scores and patient activation as observed in the multivariable analysis of the GP sample. Unlike the GP sample, a positive frailty flag was strongly associated with low HRQoL, while high resource utilisation in the past year ('unscaled concurrent risk') and the subsequent 2 years ('probability persistent high user') were not. High scores in the variable indicating risk of high resource utilisation in the following year ('total cost predicted risk') or being flagged as frail were associated with the lowest self-rated health scores.

Strengths and limitations

The study applied comprehensive and high-quality registry data of healthcare utilisation[24] and recognised and validated SROMs. This provides a complete overview of healthcare utilisation and associated diagnosis codes, as well as reliable measures of the participants' self-perceived health state. Moreover, the study applied the recognised and extensively used ACG system, which enhances the relevance and applicability of the findings of the study.

However, it must be noted that the observational design precludes establishing causal relationships. It is also important to consider that the data are from 2013 and 2014, but no major changes in coding practices since then are known. While the responder analysis revealed only minor differences between respondents and non-respondents, only about one in four responded to the survey with the SROMs. Thus, the associations identified might only be generalisable to group of individuals similar to the sample in this study, and not the whole population. Moreover, the study focuses on three specific SROMs and one risk stratification system, and caution must thus be made when generalising the results to other measures or systems.

Table 3 Age, sex and ACG risk scores for participants with low self-reported score on PAM, EQ-5D and self-rated health compared with the other participants (n=2944)

	PAM		EQ-5D		Self-rated health	
Variable	**High score (n=2165)**	**Low score (n=379)**	**High score (n=2621)**	**Low score (n=237)**	**High score (n=2704)**	**Low score (n=210)**
Age group (years)		p<0.001		p=0.032		p<0.001
18–44 years	498 (23.0%)	78 (20.6%)	643 (24.5%)	48 (20.2%)	658 (24.3%)	44 (20.9%)
45–64 years	787 (36.3%)	100 (26.4%)	900 (34.3%)	87 (36.7%)	943 (34.9%)	59 (28.1%)
65–74 years	511 (23.6%)	77 (20.3%)	608 (23.2%)	45 (19.0%)	627 (23.2%)	40 (19.0%)
75–84 years	269 (12.4%)	91 (24.0%)	346 (13.2%)	37 (15.6%)	352 (13.0%)	42 (20.0%)
85+ years	100 (4.6%)	33 (8.7%)	124 (4.7%)	20 (8.4%)	124 (4.6%)	25 (11.9%)
Sex		p=0.436		p<0.001		p=0.106
Male	936 (43.2%)	172 (45.4%)	1153 (44.0%)	67 (28.3%)	1159 (42.9%)	78 (37.1%)
Female	1229 (56.8%)	207 (54.6%)	1468 (56.0%)	170 (71.7%)	1545 (57.1%)	132 (62.9%)
Resource utilisation band		p=0.087		p=0.002		p<0.001
1	132 (6.1%)	23 (6.1%)	189 (7.2%)	7 (2.9%)	193 (7.1%)	8 (3.8%)
2	537 (24.8%)	76 (20.0%)	683 (26.1%)	43 (18.1%)	704 (26.0%)	35 (16.7%)
3	1374 (63.5%)	248 (65.4%)	1697 (61.0%)	171 (72.1%)	1661 (61.4%)	145 (69.0%)
4	115 (5.3%)	29 (7.6%)	144 (5.5%)	14 (5.9%)	138 (5.1%)	20 (9.5%)
5	7 (0.3%)	3 (0.8%)	8 (0.3%)	2 (0.8%)	8 (0.3%)	2 (0.9%)
Unscaled ACG concurrent risk		p=0.083		p<0.001		p<0.001
0–0.49	776 (35.8%)	121 (31.9%)	1010 (38.5%)	65 (27.4%)	1039 (38.4%)	58 (27.6%)
0.5–0.99	868 (40.1%)	143 (37.7%)	1024 (39.1%)	84 (35.4%)	1059 (39.1%)	70 (33.3%)
1–1.99	404 (18.7%)	84 (22.2%)	441 (16.8%)	72 (30.4%)	466 (17.2%)	61 (29.0%)
2–3.99	107 (4.9%)	28 (7.4%)	135 (5.2%)	14 (5.9%)	130 (4.8%)	19 (9.0%)
≥4	10 (0.5%)	3 (0.8%)	11 (0.4%)	2 (0.8%)	11 (0.4%)	2 (0.9%)
Unscaled concurrent risk		p=0.030		p<0.001		p<0.001
0–0.49	1125 (52.0%)	180 (47.5%)	1441 (55.0%)	95 (40.1%)	1 491 (55.1%)	80 (38.1%)
0.5–0.99	420 (19.4%)	65 (17.1%)	471 (18.0%)	54 (22.8%)	500 (18.5%)	35 (16.7%)
1–1.99	360 (16.6%)	80 (21.1%)	414 (15.8%)	49 (20.7%)	424 (15.7%)	49 (23.3%)
2–3.99	186 (8.6%)	32 (8.4%)	209 (8.0%)	28 (11.8%)	212 (7.8%)	25 (11.9%)
≥4	74 (3.4%)	22 (5.8%)	86 (3.3%)	11 (4.6%)	77 (2.8%)	21 (10.0%)
Unscaled total cost predicted risk		p<0.001		p=0.004		p<0.001
0–0.49	236 (10.9%)	33 (8.7%)	324 (12.4%)	16 (6.7%)	332 (12.3%)	15 (7.1%)
0.5–0.99	600 (27.7%)	78 (20.6%)	740 (28.2%)	56 (23.6%)	770 (28.5%)	39 (18.6%)
1–1.99	766 (35.4%)	127 (33.5%)	900 (34.3%)	83 (35.0%)	947 (35.0%)	60 (28.6%)
2–3.99	481 (22.2%)	117 (30.9%)	561 (21.4%)	68 (28.7%)	566 (20.9%)	75 (35.7%)
≥4	82 (3.8%)	24 (6.3%)	96 (3.7%)	14 (5.9%)	89 (3.2%)	21 (10.0%)
Probability persistent high user (%)		p=0.015	p<0.001			p<0.001
0–9	2041 (94.3%)	342 (90.2%)	2485 (94.8%)	207 (87.3%)	2568 (95.0%)	177 (84.3%)
10–14	86 (4.0%)	24 (6.3%)	93 (3.5%)	23 (9.7%)	91 (3.4%)	25 (11.9%)
15–19	24 (1.1%)	10 (2.6%)	29 (1.1%)	5 (2.1%)	34 (1.3%)	1 (0.5%)
20+	14 (0.6%)	3 (0.8%)	14 (0.5%)	2 (0.8%)	11 (0.4%)	7 (3.3%)
Major ADG count (mean)	0.48 (SD: 0.63)	0.59 (SD: 0.69, mean diff 0.12 (0.05–0.19))	0.45 (SD: 0.62)	0.60 (SD: 0.70, mean diff 0.15 (0.07–0.24))	0.44 (SD: 0.61)	0.75 (SD: 0.73, mean diff 0.31 (0.22–0.40))
Chronic condition count (mean)	0.97 (SD: 0.97)	1.18 (SD: 1.13, mean diff 0.22 (0.11–0.33))	0.90 (SD: 0.97)	1.32 (SD: 1.13, mean diff 0.42 (0.29–0.55))	0.90 (SD: 0.95)	1.42 (SD: 1.27, mean diff 0.52 (0.38–0.66))
Diagnoses used (mean)	3.81 (SD: 2.34)	4.20 (SD: 4.20, mean diff 0.39 (0.13–0.65))	3.65 (SD: 2.32)	5.05 (SD: 2.91, mean diff 1.40 (1.08–1.71))	3.67 (SD: 2.32)	4.87 (SD: 2.96, mean diff 1.21 (0.87–1.54))

Continued

Table 3 Continued

Variable	PAM		EQ-5D		Self-rated health	
	High score (n=2165)	Low score (n=379)	High score (n=2621)	Low score (n=237)	High score (n=2704)	Low score (n=210)
Frailty flag		p=0.004		p=0.048		p<0.001
Yes	59 (2.7%)	21 (5.5%)	73 (2.8%)	12 (5.1%)	72 (2.7%)	15 (7.1%)

Numbers are n (%), mean (SD), p value or mean difference (95% CI).
ACG, Adjusted Clinical Group; ADG, Adjusted Diagnosis Group; EQ-5D, EuroQol 5-dimension; PAM, Patient Activation Measure.

Discussion of findings

Previous studies have reported associations between patient activation and HRQoL,[25] patient activation and self-rated health[26] and self-rated health and various HRQoL measures.[27] This raises the question of whether any of the three SROMs applied in this study could have been omitted. However, the fact that the respective measures largely identified different individuals (figure 1) suggests that each SROM, at least partially, measures unique aspects. A possible explanation for the differences between these findings and studies showing associations between the SROMs[25–27] could be our focus on the individuals with the lowest scores. Thus, this discussion focuses on how the association between different ACG scores and low scores in each of the SROMs can be understood and explained.

Patient activation is deemed essential for patients to actively engage in, and consequently improve, their quality of care,[14] a process shown to be a valuable intervention target.[28] Having the highest scores (≥2) in the ACG 'unscaled total cost predicted risk' variable was associated with low PAM scores. A plausible explanation is that high patient activation has been linked to reduced costs,[17 29] most likely mediated through patient behaviours such as successful self-management. This is especially crucial for individuals with unstable chronic conditions who more frequently use emergency care.[30] There were also an association between the ACG frailty flag and low patient activation. Being in the lowest level of patient activation is described as lacking the confidence in one's ability to manage his or her health, and not feeling in charge of own health and care.[14] This

Table 4 Unadjusted and adjusted association between ACG risk stratification scores and low PAM, EQ-5D and self-rated health scores

Variable	PAM		EQ-5D		Self-rated health	
	Crude OR	Adjusted OR (95% CI)	Crude OR	Adjusted OR (95% CI)	Crude OR	Adjusted OR (95% CI)
Resource utilisation band						
1	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
2	0.81	0.76 (0.45 to 1.28)	1.70	1.51 (0.66 to 3.47)	1.20	1.07 (0.48 to 2.40)
3	1.04	0.80 (0.47 to 1.35)	2.89*	1.99 (0.86 to 4.59)	2.11*	1.23 (0.55 to 2.77)
≥4	1.51	0.89 (0.43 to 1.86)	2.84*	0.89 (0.31 to 2.54)	3.64*	1.26 (0.49 to 3.28)
Unscaled concurrent risk						
0–0.49	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
0.5–0.99	0.97	0.86 (0.62 to 1.19)	1.74*	1.44 (0.99 to 2.09)	1.30	1.10 (0.71 to 1.69)
1–1.99	1.39*	0.95 (0.67 to 1.34)	1.80*	1.30 (0.85 to 1.99)	2.15*	1.31 (0.84 to 2.03)
≥2	1.30	0.82 (0.54 to 1.25)	2.00*	1.60 (0.99 to 2.58)	2.97*	1.77 (1.09 to 2.86)*
Unscaled total cost predicted risk						
0–0.49	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
0.5–0.99	0.93	0.99 (0.63 to 1.55)	1.53	1.20 (0.66 to 2.17)	1.12	1.05 (0.56 to 1.99)
1–1.99	1.19	1.27 (0.80 to 2.00)	1.87*	1.21 (0.66 to 2.20)	1.40	1.21 (0.64 to 2.28)
≥2	1.79*	1.80 (1.08 to 2.98)*	2.53*	1.20 (0.62 to 2.32)	3.24*	2.14 (1.10 to 4.16)*
Probability persistent high user (%)						
0–9	Ref.	Ref.	Ref.	Ref.	Ref.	†
≥10	1.78*	1.33 (0.83 to 2.14)	2.65*	2.83 (1.67 to 4.80)*	3.52*	
Frailty flag						
No	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Yes	2.09*	1.76 (1.08 to 2.98)*	1.86*	1.62 (0.85 to 3.11)	2.81*	1.82 (1.01 to 3.30)*

*P value <0.05.
†Probability persistent high user was not included in the multivariable analysis of self-rated health.
ACG, Adjusted Clinical Group; EQ-5D, EuroQol 5-dimension; PAM, Patient Activation Measure.

relationship between frailty and low perceived self-control has been documented in a population-based study.[31]

HRQoL is a useful metric for identifying those most affected by their health state,[32] which aligns well with our finding that having the highest scores in the ACG variables estimating the risk of high concurrent resource utilisation and the probability of having high resource utilisation for the two subsequent years were associated with having the lowest HRQoL. The reason could be that having low HRQoL is both an expression of current healthcare needs that cause increased healthcare utilisation, and that this could endure over time and cause persistent high utilisation.

Given the strong association between SRH, mortality and morbidity, SRH is proposed to better reflect biological health status better than medical diagnoses alone.[33] Our findings showed that high scores in the ACG variables unscaled concurrent risk and unscaled total cost predicted risk and receiving a positive frailty flag were associated with reporting poor SRH. It has been found that self-rated health predicts high healthcare costs in the following year better than administrative data alone,[34] and that it predicts population level risk of high expenditure.[35] This is a likely explanation for the association with the ACG variable concurrent risk. This explanation is also likely to hold for the association with unscaled total cost predicted risk, as SRH has been reported to remain fairly stable over time.[36] SRH has also previously been reported to be linked to frailty, as suggested by the findings of the present study. Both Pilleron *et al*[37] and Chu *et al*[38] have reported linkages between SRH and concomitant or subsequent frailty. The latter has also proposed SRH as a tool for predicting frailty.[38]

The hospital sample received higher ACG risk scores than the GP sample, and showed many of the same associations. The difference was that high scores in the unscaled concurrent risk and probability persistent high user scores were not significantly associated with neither the lowest EQ-5D scores nor the lowest SRH scores. Also, a positive frailty flag was strongly associated with the lowest EQ-5D scores and the highest scores in the unscaled total cost predicted risk variable was strongly associated with the lowest SRH scores. The mechanisms proposed above are likely to hold also in the hospital sample.

We initiated this study to explore whether ACG risk scores could be used as proxies for SROMs when screening the population to identify individuals with complex or long-term conditions eligible for care management interventions, that is, if ACG variables were associated with low scores in different SROMs. Our findings suggest that, if confirmed, population health managers could use the ACG variables associated with the SROM most relevant for identifying participants for a specific intervention. Another application could be to estimate the number of individuals in the population with low SROM scores for resource allocation purposes.

CONCLUSIONS

This study found associations between some ACG risk scores and subsequent low scores in SROMs. Potential mechanisms for explaining these associations are suggested in the existing research literature. These findings indicate a potential to use diagnosis-based risk stratification systems as proxies for SROMs when screening the population to identify individuals with low self-perceived health eligible for healthcare intervention.

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