Multimorbidity and its measurement

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\textbf{A R T I C L E   I N F O}

\textbf{Keywords:}
Multimorbidity
Primary care
Case-mix
ACG System

\textbf{A B S T R A C T}

Multimorbidity is increasing in frequency. It can be quantitatively measured and is a major correlate of high use of health services resources of all types, especially over time. The ACG System for characterizing multimorbidity is the only widely used method that is based on combinations of different TYPES of diagnoses over time, rather than the presence or absence of particular conditions or numbers of conditions. It incorporates administrative data (as from claims forms or medical records) on all types of encounters and is not limited to diagnoses captured during hospitalizations or other places of encounter. It can be employed in any one or combination of analytic models, and can incorporate medication use if desired. It is being used in clinical care, management of health services resources, in health services research to control for degree of morbidity, and in understanding morbidity patterns over time. In addition to its research uses, it is being employed in many countries in various applications as a policy to better understand health needs of populations and tailor health services resources to health needs.

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1. Introduction

Multimorbidity is rapidly becoming the norm in modern society. At the same time as life expectancy is increasing (especially in developing countries), the increasing survival as a result of environmental and medical advances is leading to an increased prevalence of many diseases and an increase in the co-existence of multiple diseases. Even though morbidity increases with age, the non-chance coexistence of multimorbidity is greater at younger ages [1], undoubtedly because highly vulnerable populations (such as young children) are more prone to various types of illnesses. An increase in the number and type of environmental, social, and personal risks is contributing to a very rapid rise in multimorbidity because the same risks are associated with a vulnerability to a wide variety of illnesses ("pleiotropism") [2].

Co-morbidity (having one or more additional illnesses in the presence of any given illness) has been well-recognized as an important epidemiologic phenomenon for at least 40 years [3], with the preponderance of literature dealing with the co-existence of mental and physical health conditions. It is only relatively recently that the coexistence of many different illnesses and types of illnesses has been recognized.

In view of the heavy burden that multimorbidity places on the health system [4], methods to document it so that it can become a target for appropriate interventions are needed. It is the purpose of this paper to describe the only existing measure of multimorbidity that characterizes illnesses by their type and by their combinations of types. As the method [5] is of interest and is in increasing use internationally, a summary of its characteristics and applications is in order.

2. Materials and methods: development of the ACG\textsuperscript{®} System

In the 1960s and 1970s, a series of studies were designed to determine why a certain proportion of the population
persisted in a pattern of high use of services. These studies concluded that the number of different types of illnesses (acute, acute but recurrent, chronic medical, chronic surgical, and mental health problems) experienced in a year was the best predictor of subsequent high use and costs of services [6]. Subsequent efforts involved categorizing all diagnoses in the International Classification of Diseases 9th edition (and adding new diagnoses with each ICD update and revision) into 32 different types. Table 1 lists the different groupings, designated as ADGs (Aggregated Diagnosis Groups). These 32 ADGs were collapsed based on clinical judgment of likelihood of persistence or recurrence over time, likelihood of return visits, likelihood of requiring specialty services, expected need for and use of diagnostic or therapeutic procedures, likelihood of hospitalization, and likelihood of disability or decreased life expectancy. This resulted in the 11 CADGs (Collapsed Aggregated Diagnosis Groups), which are similar types of diagnoses (such as acute self-limited, acute recurrent, chronic conditions, eye conditions, psychosocial conditions), and one additional CADG comprising common combinations of the 11 other groups, to make 12 in all. Recursive computerized partitioning, which also included age, gender, and number of individual ADGs led to about 50 groupings—a parsimonious set considering that there are many millions of different combinations of 32 groupings, age, and gender. Other categories (such as various pregnancy codes and low birth weight groups) were subsequently added to obtain about 100 unique mutually exclusive combinations of conditions (designated as ACGs (Adjusted Clinical Groups) occurring in individuals over a period of time, usually a year) [7]. Thus, people can be characterized by their pattern of diagnosis in a period of time. This characterization is based on their diagnoses (not on their use of services) as captured from routinely obtained records such as insurance forms or computerized medical encounter records. By aggregation across individuals, the burden of morbidity in a population can be ascertained. Although the original system was applied only to primary care data, it has been expanded to include specialty services as well. Several studies confirmed the utility of this measure for describing concurrent use of services and predicting future use of services over several years [8–11]. Fig. 1 shows the components of the current algorithm, which includes subsequent enhancements to the ACG System. Work is underway to incorporate problems that are likely to be associated with adverse medication events.

3. Results: utility of the ACG System for measurement of morbidity burden

Compared with other methods for characterizing morbidity, the ACG System has relatively high predictability [12], despite the fact that much of illness is unpredictable. As it is known that socially disadvantaged populations have higher illness rates, it is a measure of the validity of the ACG System that, on an area-wide basis, the distribution of morbidity burden reflected in claims forms was the same as the distribution of social class in areas of Manitoba, Canada, thus indicating that the system is able to capture the greater morbidity of socially disadvantaged population groups [13]. In fact, the ACG morbidity measure was by far the major predictor of standardized area mortality in an analysis that also considered SES and primary care and specialist utilization rates. Fowles et al. [14] showed that the SF-36 score for health as reported on patient surveys mirrors the number of ADGs; the larger the number of ADGs,

Table 1
Ambulatory diagnostic groups (ADGs).

| Time limited (4)                      |
| Likely to recur (3)                   |
| Chronic medical (2)                   |
| Chronic specialty (6)                 |
| Injuries (2)                         |
| Psychosocial/psychophysiologic (3)   |
| Signs/symptoms (3)                   |
| Allergies                             |
| Asthma                                |
| Malignancy                            |
| Dermatologic                          |
| Discretionary                         |
| See and reassure                      |
| Preventive/administrative             |
| Pregnancy                             |
| Dental                                |

Total number of ADGs = 32

Fig. 1. Risk factors in the Johns Hopkins Diagnosis-Based Predictive Model (Dx-PM). http://www.acg.jhsph.org/index.php?option=com_content&view=article&id=59&Itemid=150.
the poorer the reported health in all domains (general health, vitality, emotional roles, social functioning). Sibley and Glazier [15] showed with data from Ontario, Canada that ACG-weighted data does a better job of predicting differences in mortality across social classes than does an age-sex derived capitation payment. A study involving the entire population of Ontario, Canada (10.5 million people) showed that ADG assignment using two prior years of data from all health care encounters was highly predictive of death in the following year, surpassing assignments made on the basis of high-profile individual conditions [16]. In Taiwan, the entire population was divided into morbidity trajectories derived by assigning an ACG to each individual and then categorizing each individual into a high, medium, and low resource use group for each of three years. Confirming an earlier study [10], the analyses found relative stability of morbidity trajectories over time: despite the considerable unpredictability of illness occurrence, over 80% of the population either remained in the same group (48%), had progressively increasing morbidity burdens (19%), or had decreasing morbidity burdens (17%) as compared with chance (“expected”) distributions of 15%, 26%, and 25%, respectively [17].

4. Studies using the ACG System to understand the role of multimorbidity in resource use

The ACG System has been used in a variety of studies to ascertain variability in use of interventions, examine differences in primary care and specialty use, carry out epidemiologic studies of illness, and control for morbidity in health services research. This section provides examples of each.

Salem-Schatz et al. [18] studied referrals for 38,000 patients, controlling for morbidity burden by using the number of different ADGs. They demonstrated that variability in referrals across physicians is significantly reduced when patient multimorbidity is taken into account. That is, much of the variability can be accounted for by differences in patient needs. Reid [19] used ADGs and ACGs separately with data from Alberta, Canada, and also showed reductions in referral rate variability after morbidity mix control. Forrest et al. [20] used the ACG designations to show the much larger percentage of people receiving specialist care (after controlling for differences in morbidity burden) in the US as compared with the UK. Sicras-Mainar et al. [21] used ACGs to show that variability in referrals is greatly reduced after taking into account differences in morbidity burden. Aguado et al. [22] used groupings of ACGs, known as RUBs (Resource Utilization Bands) to show that the variation in prescription drug use across 5 primary care centers in Spain is greatly reduced after controlling for differences in morbidity burden.

Starfield et al. [23] examined medical records using ACGs as the measure of morbidity burden of patients seen by 135 physicians. They found no consistent relationship between quality of care (using well-accepted disease and generic criteria) and charges for care; overall, community health centers were found to provide better quality of care (when compared with private physicians and hospital-based clinics) after controlling for differences in morbidity burden. Powe et al. [24], using the same data base and morbidity burden measure, also found no relationship between costs and quality for three chronic illnesses. Starfield et al. [25] showed, after controlling for morbidity using the ACGs divided into 3 groups (high, medium, and low), that primary care physicians are seen more than specialists in the US at all morbidity burden levels but, among those of ages 65 and over, specialists in that country play a major role except in people with low overall burdens of morbidity. Starfield et al. [26] used a variety of approaches available in the ACG System (number of ADGs, trichotomized; presence or absence of each of the ADGs, number of different types of morbidity dichotomized as 1–10 and 11+; alternative cutoffs for low; medium, and high morbidity; and the ACGs) to examine the use of primary care and specialist visits (as well as the proportion of people with such visits). They showed that the larger the number of different primary care physicians seen, the more the number of specialists seen; also, the greater the number of specialist visits, the greater the use of resources, after controlling for degree of morbidity burden regardless of the method of applying the ACG System.

In British Columbia, Canada, Hollander et al. [27] used the ACG System to control for differences in morbidity burden for people with diabetes or congestive heart failure and found that greater affiliation of people with a particular primary care physician greatly reduces costs. The benefit especially accrues from savings among people with high burdens of morbidity as measured by the ACG System. In the US (where most people can go directly to specialists), individual specialists see patients with less severe individual diseases than do generalists, when viewed from the vantage of disease-oriented specialty practice [28], but specialists as a group dominate the care of people with high burdens of morbidity, because people with high burdens of morbidity often see multiple specialists. Thus, a disease-by-disease approach to understanding use of services provides a distorted view of the health needs of the population and the challenges to coordinate care through primary care practice.

Accumulating evidence indicates that resource use is NOT primarily a result of an increase in chronic illness, but because of interventions in the presence of multiple TYPES of morbidity. Broemeling et al. [29], using data from British Columbia, Canada, classified diseases as acute, chronic, and serious chronic, and used the ACG System to characterize each individual in the British Columbia population according to their degree of morbidity burden. The findings convincingly showed, after stratifying for type of illness, that increased use of resources was linearly associated with greater degrees of morbidity burden. Within each stratum of morbidity burden, there was no difference in the use of resources by type of illness. In Israel, Shadmi et al. [30] used the number of ADGs, as well as a chronic condition count and another index of number of specific illnesses to characterize adults and compare their costs and use of services. Almost one-third of people with no chronic conditions had an average use ratio higher than people with 5 or more chronic conditions. Some people with as many as 6 chronic conditions (including 80% of people with hypertension, 70% of people with hyperlipidemia,
over 40% of people with diabetes, and about one-third of people with osteoporosis) had less than average resource use. Resource use (including total costs, hospital costs, ambulatory costs, specialist visits, and primary care visits) increased more than linearly with increasing morbidity burden, at every stratum of number of chronic conditions (0–4 or more).

5. What could morbidity oriented assessments accomplish in health systems?

Past research indicates that morbidity burden assessment could add considerably to the ability of health systems to make better use of data for planning and evaluation. It would, for the first time, make it possible to identify sources of variation in health status and health resource use that are NOT a result of individual patient characteristics; focus attention on the likelihood of systematic differences in resource use across population groups that are NOT due to morbidity differences; focus attention on health system and provider characteristics that are associated with various patterns of morbidity; focus attention on the limitations of clinical guidelines (which are almost always oriented toward specific single diseases); and focus attention on adverse events in the presence of overall morbidity burden. They could also shed considerable light on changing patterns of diseases concomitant with the thrust of health systems to diagnosis disease earlier and earlier [31].

Current uses of the ACG System in health care systems worldwide reflect the numerous applications for which the system was designed; namely, profiling of populations, assessment of provider practices, more equitable resource allocation, high-risk patient identification, and monitoring of interventions and policy reforms as well as evaluating existing systems.

Profiling of populations – The monitoring of morbidity burden across populations has facilitated comparisons of population segments in Israel, across both regional boundaries and socio-economic groups as well as by ethnicity, with insights into the presence of variance in disease prevalence that enable more targeted interventions [32].

Profiling of providers – Recognizing that physicians’ practice behavior varies [33], the Ministry of Health in British Columbia, Canada, has used the ACG System to evaluate physicians and detect true cases of fraud and abuse. Prior to the introduction of the ACG System, audit results showed that, in 3 out of 4 cases, high healthcare expenses were justified by a sicker patient pool. After the ACG System was extensively evaluated, subsequent audit results showed that unjustified healthcare expenses were actually confirmed in 3 out of 4 cases identified [34].

Resource allocation – Perhaps the most common administrative use of the ACG System is in the distribution of budgets – both regionally (as in Sweden) as well as to individual clinics (as in Spain). In Sweden, where people were given the choice of a public or a private primary care provider, those choosing to stay with a public primary care provider had higher morbidity burdens as determined by the ACG method [35]. By applying case-mix to payment formulas, a health care authority is able to ensure that payment is provided according to the needs of patients [36].

High risk patient identification – This application has been gaining in importance as demonstrated by experiences in Germany and the US as well as the UK. Given the limited resources present in every health care system, targeting individuals who could most benefit by early detection and intervention is a prudent way to utilize these limited resources [37].

Monitoring of policy reform measures – In 2005, the Swedish government passed legislation allowing individuals to choose their provider. An analysis of the morbidity patterns of those individuals who remained with their existing provider compared with those who choose to switch providers, showed that those who remained with their existing provider had a higher morbidity burden [35].

Evaluation of data capture systems – When an Asian Ministry of Health implemented its EMR system in 2005, they used the ACG System to take advantage of their new database. When the ACG System output indicates inaccuracies in the data collected, improvements were able to be made to their EMR system to make the data more valid.

Adoption of the ACG System for policy and administrative use is burgeoning. Despite differences in health care systems, the ACG System has demonstrated that it is robust in its ability to measure morbidity burden in individuals and populations. As of 2011, in addition to wide use across the US, it is being used in several provinces in Canada, numerous county councils in Sweden, several regions of Spain, multiple primary care trusts in the UK, sickness funds in Germany, the largest health plan in Israel, two medical schemes in South Africa, and the Ministry of Health in Malaysia. There is active piloting in Denmark, Turkey, Chile, and Hong Kong as well as research in Scotland, Belgium, Lithuania, Korea, Taiwan, Japan, and Thailand. The software has been customized to numerous diagnostic coding systems (ICD-9, ICD-10, Read, and the ICPC (International Classification of Primary Care)) as well as multiple pharmaceutical coding systems (NDC, ATC, and BNF). It is a proven tool to enable understanding of new imperatives in characterization of illness to improve the appropriate targeting of resources in health systems.

6. Discussion

These analyses using the ACG System make it clear that morbidity is not randomly distributed in the population. Although this is not a new finding, previous analyses of this phenomenon were based on deaths from specific causes. What these analyses indicate is that populations with high vulnerability to illness (from whatever influences on health) are even more disadvantaged than can be ascertained by a disease-by-disease approach because of the way morbidity clusters in these subpopulations. It is also clear that morbidity burden is of even greater utility in explaining resource consumption than the sum of costs for different diseases.

Wider use of such a morbidity burden measure would help to answer many important questions in planning for health services.
7. Application of electronic data to multimorbidity measurement

Despite the benefits identified in applying the ACG System to routinely collected data, it is impractically cumbersome to use non-computerized data. The importance of implementing a standardized EMR or claim system is not limited to the ability to use analytical tools, such as the ACG System, and should be considered a critical component of any health care system. Data converted to actionable information supports more informed clinical, financial, and managerial decisions.

Identifiable populations form the basis for utility of electronic data systems. The ACG System captures the entire experience (across all health sectors), including all aspects of health of the entire population. In order to link data streams from various health care providers, a unique patient identifier is necessary.

Perhaps the most critical component to successfully implement the measurement of morbidity burden is political will. Policy reform implies a change from the status quo. The recognition of the value incorporated in scientifically based information is an important first step to overcoming resistance to change on the part of various stakeholders. When initiated in primary care and then incorporating other levels of care, this information base is an invaluable technology for understanding illness and planning for care in health systems.

8. Conclusion

In view of the increasing role of multimorbidity in the provision of health services, a method that is able to reliably reflect the different types and combinations of illnesses that contribute to the use of health services over time is essential. As has been proven in experiences worldwide, the ease of obtaining and using the data needed to characterize multimorbidity make the ACG System a preferred method for analyses in different domains and for comparison across areas within and between countries.

Disclaimer

The Johns Hopkins University has copyrighted software based on the ACG System mentioned in this article. Royalties are paid to the university when this software is used by insurance plans and commercial organizations. The authors are faculty members of the Johns Hopkins University.

Acknowledgements

The authors would like to acknowledge Normalie Barton for her assistance in preparing the manuscript.

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