

# The Measurement of Multiple Chronic Diseases—A Systematic Review on Existing Multimorbidity Indices

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**Background.** Multimorbidity, defined as the coexistence of 2 or more chronic diseases, is a common phenomenon especially in older people. Numerous efforts to establish a standardized instrument to assess the level of multimorbidity have failed until now, and indices are primarily characterized by their high heterogeneity. Thus, the objective is to provide a comprehensive overview on existing instruments on the basis of a systematic literature review.

**Methods.** The review was performed in MedLine. All articles published between January 1, 1960 and August 31, 2009 in German or English language, with the primary focus either on the development of a weighted index or on the effect of multimorbidity on different outcomes, were identified.

**Results.** A total of 39 articles met the inclusion criteria. In the majority of studies (59.0%), the list of included diseases was presented without any selection criteria. Only the high prevalence of diseases (17.9%), their impact on mortality, function, and health status served as a point of reference. Information on the prevalence of chronic conditions mostly rely on self-reports. On average, the 39 indices included 18.5 diseases, ranging between 4 and 102 different conditions. Most frequently mentioned diseases were diabetes mellitus (in 97.5% of indices), followed by stroke (89.7%), hypertension, and cancer (each 84.6%). Overall, three different weighting methods could be distinguished.

**Conclusions.** The systematic literature further emphasizes the heterogeneity of existing multimorbidity indices. However, one important similarity is that the focus is on diseases with a high prevalence and a severe impact on affected individuals.

**Key Words:** Multimorbidity—Index—Chronic diseases—Systematic review.

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DESPITE the growing number of people suffering from multiple chronic diseases, methodological problems concerning the measurement of multimorbidity still persist (1). Until recently, even the terms comorbidity and multimorbidity were used interchangeably by many authors (2). Only in the last few years, a clear distinction between the two terms has become widely accepted. Whereas comorbidity is defined as the “existence or occurrence of any distinct additional entity during the clinical course of a patient who has the index disease under study” (3), multimorbidity describes “the coexistence of two or more chronic diseases” in the same individual (4). These established definitions also provide the basis for the following study, which exclusively focuses on multimorbidity indices.

Apart from this problem, clear and comprehensive criteria for the selection of chronic conditions, which qualify for multimorbidity, are still lacking. Accordingly, there is no agreement on the number and type of diseases to be included in multimorbidity indices (5). Existing instruments are characterized by their large heterogeneity, ranging from considering only a few—for example the four diagnoses stroke, coronary

heart disease, hypertension, and diabetes (6)—up to 185 different diseases (7). This results in noncomparable information on prevalences of multimorbidity across studies, ranging from 23 % in primary care patients in the Netherlands (8) to 98% in male and 99% in female patients in the ambulant sector in Canada (9). Furthermore, in many indices, diseases are weighted differently, either according to their individual severity (10) or their influence on other outcomes, such as mortality (11), hospital stays (12), or quality of life (13).

Although no “gold standard” for measuring the rather complex phenomenon multimorbidity has been established so far, numerous instruments exist, which are widely used in health research. The most frequently applied index is the “Charlson Index” (11). Its primary objective is to establish a prognostic instrument for chronic conditions that individually or in combination might alter the risk of death. Other authors (14) assess the level of impairment caused by conditions, by asking the respondents to report for each disease whether it interferes with their daily activities. More complex indices, such as the “Index of Coexisting Disease”,

measures the severity of 14 chronic diseases and the resulting functional limitations in two separate steps (15).

By using these instruments, research on multimorbidity has so far primarily focused on analyzing the impact of multiple chronic conditions on the individual. Thus, strong evidence exist that the coexistence of multiple chronic conditions increases the mortality risk (16), causes a decline of physical and mental functioning (13,17), and negatively influences quality of life (18). Furthermore, it is associated with longer hospital stays, postoperative complications (19), and a higher overall health care utilization (20). In contrast to this rather advanced research on the effects—and to a lesser extent on risk factors—of multimorbidity, only few studies have explicitly concentrated on methodological questions, such as defining criteria for the selection of diseases.

Thus, a first step toward the development of a gold standard for the assessment of multimorbidity is the provision of in-depth knowledge on the state of the art of existing indices on the basis of a systematic literature review. In consideration of the heterogeneity of multimorbidity indices, we focused the review on two distinctive types of studies. First of all, we selected methodological studies that are exclusively concerned with the “development of weighted multimorbidity indices.” Secondly, we identified studies that analyze the “impact of multimorbidity on different outcomes specifically in the general population.” We chose this narrow approach in order to reasonably limit the review on studies with common objectives or the same study population.

By using both types of studies, we provided a general overview on the following topics:

1. Are there any criteria specified for the selection of chronic diseases?
2. What kind of data source is used?
3. How many diseases are considered in multimorbidity indices?
4. What type of diseases is included in the selected indices?

By solely looking at the identified weighted indices, we further investigated research questions with a methodological focus:

1. What kind of study population is used for the development of multimorbidity indices?
2. What kind of weighting methods is applied in multimorbidity indices?

## METHODS

A systematic literature review was performed in MedLine (U.S. National Library of Medicine) to identify articles that first of all focus either on the development of a weighted multimorbidity index or secondly that analyze the impact of multimorbidity as the independent variable on different outcomes in the general population. We only included studies, which referred to multimorbidity in the sense of the “coexistence of two or more chronic diseases”

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("1960/01/01"[PDAT] : "2009/08/31"[PDAT]) AND ("Comorbidity"[MeSH Major Topic]
OR multimorbid OR multimorbidity OR multimorbidities) AND ("humans"[MeSH Terms]
AND (English[lang] OR German[lang]))
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Figure 1. Search algorithm for the systematic literature review.

(4) and did not consider comorbidity indices, which were exclusively developed for specific index diseases.

The search strategy was restricted on articles, which were published between January 1, 1960 and August 31, 2009 in German or English language. Because none of the terms “multimorbid,” “multimorbidity,” or “multimorbidities” were prespecified as Medical Subject Headings, they were all linked by the logical operator “OR” for the search algorithm.

Because the term comorbidity is often used to describe the coexistence of multiple diseases (13,21), we also added “Comorbidities” as a Medical Subject Headings’ term to the search algorithm. The final algorithm is presented in Figure 1.

After a review of all titles and abstracts, we excluded editorials, letters to the editor, reviews, and articles, which did not primarily focus on the relevant type of multimorbidity studies. In the second selection process, we reviewed the whole articles. One inclusion criterion was that the study contained an explicit list of chronic diseases to account for multimorbidity.

Due to the large variety of studies, which compared frequently applied indices, validated them in regard to different outcomes or populations, (11,22) or used slightly modified indices (23), we only included the original indices.

Figure 2 displays a comprehensive overview on the selection process.

## RESULTS

The systematic literature review resulted in 1,120 articles. After the first two selection steps, 32 studies were rated as relevant. Their references included another seven studies, which met the inclusion criteria. Thus, the final literature basis consisted of 39 (100.0%) different multimorbidity indices.

From these 39 studies, 21 were identified that analyze the association between multimorbidity and different outcomes in the general population (Table 1). Further details are provided on data sources and outcomes studied.

Furthermore, 18 studies were identified with a methodological focus on the development of a weighted multimorbidity index. They are presented in Table 2. Detailed information is provided on the name of the index, the study populations, the data sources such as self-reports or medical records, the weighting methods, and the outcomes.

The oldest study that described the development of a multimorbidity index was published in 1974 by Kaplan and Feinstein. They presented a scheme to classify chronic conditions according to their severity into three different categories (44). The best known and most frequently applied index is the Charlson Index, which was generated as a prognostic instrument for short-term mortality resulting from coexisting chronic diseases (11).

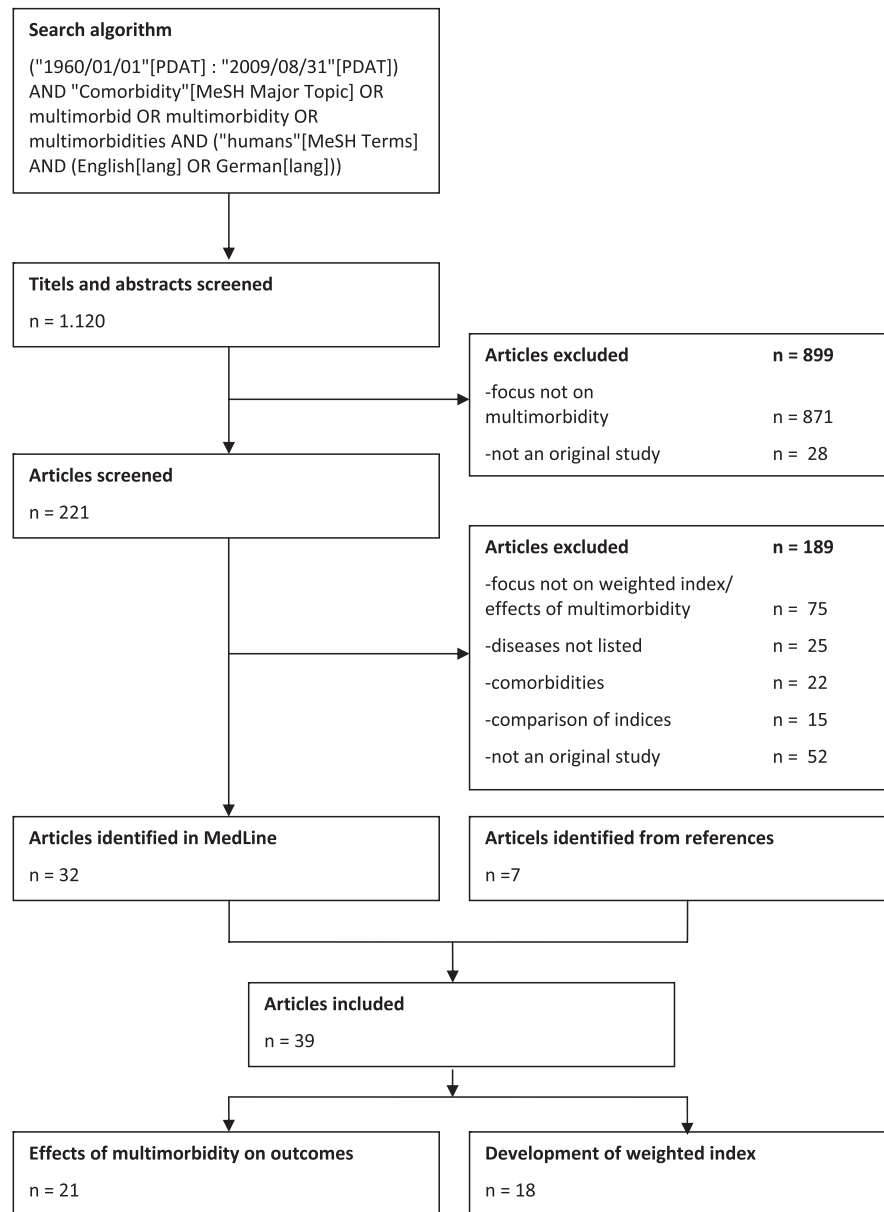


Figure 2. A comprehensive overview on the selection process.

### Selection of Criteria

In the majority of studies (59.0%), criteria for the selection of diseases were not specified. In these cases, a list of chronic conditions was presented without further explanation. In 16 articles (41.0%), one or more criteria were given. Figure 3 provides an overview on these criteria.

The most frequently used selection criterion is the high prevalence of the disease either in the general population or among study participants. This criterion is mentioned in seven out of 39 studies. In four articles, other indices serve as a reference point for the selection of diseases. Conditions, which are associated with an increased mortality risk, are included in four indices. The impact of diseases on function and health, or their need for management, is each specified in three articles.

### Data Sources

In general, self-reports, physician reports, medical records, and administrative data are used for the assessment of multimorbidity. In the identified 39 studies, information on the prevalence of chronic conditions mostly rely on self-reports (74.4%). In four studies, self-reported data are further validated by using medical records (34,50), physician reports (48), or clinical examinations (16). Medical record abstraction is used in six studies. In two unweighted indices, information on the prevalence of chronic diseases is obtained from the physicians. The Chronic Disease Score, which calculates multimorbidity scores according to the prescribed medication, is derived from administrative data (53).

Table 1. Indices Used for Analyzing the Association Between Multimorbidity and Different Outcomes in the General Population

| Author                     | Population                         | Data Sources                                                                                 | Outcome                                |
|----------------------------|------------------------------------|----------------------------------------------------------------------------------------------|----------------------------------------|
| CDC (24)                   | Population                         | Self-reports                                                                                 | Prevalence, ADL                        |
| Cesari et al. (25)         | Population                         | Self-reports                                                                                 | ADL, IADL                              |
| Fillenbaum et al. (26)     | Population                         | Self-reports                                                                                 | Mortality                              |
| Forman-Hoffman et al. (27) | Population                         | Self-reports                                                                                 | Depression, weight changes             |
| Forrest et al. (28)        | Female population                  | Self-reports                                                                                 | Driving pattern                        |
| Fried et al. (29)          | Female population                  | Self-reports                                                                                 | Physical functioning                   |
| Fuchs et al. (30)          | Population                         | Self-reports                                                                                 | ADL, IADL                              |
| Fung et al. (31)           | Population                         | Self-reports                                                                                 | Patients' ratings of communication     |
| Grimby et al. (32)         | Population                         | Physician reports, medical records                                                           | HRQoL (NHP)                            |
| Guralnik et al. (33)       | Population                         | Self-reports                                                                                 | Prevalence, ADL                        |
| Higashi et al. (34)        | Two populations and veterans       | Self-reports, medical records                                                                | Quality of care                        |
| Holman et al. (35)         | Population                         | Medical records                                                                              | Mortality, readmission, length of stay |
| Hudon et al. (36)          | Population                         | Self-reports                                                                                 | Physical activity level                |
| Marengoni et al. (17)      | Population                         | Physician report (based on clinical examination, medical history, laboratory data, drug use) | Mortality, ADL                         |
| Menotti et al. (37)        | Male population in three countries | Self-reports                                                                                 | Comparison, mortality                  |
| Merikangas et al. (38)     | Population                         | Self-reports                                                                                 | Role disability                        |
| Michelson (39)             | Population                         | Self-reports                                                                                 | HRQoL (EORTC QLQ-C3)                   |
| Min (40)                   | Population                         | Self-reports                                                                                 | Quality of care                        |
| Patel et al. (41)          | Two populations                    | Self-reports                                                                                 | Comparison, prevalence, ADL            |
| Schoenberg et al. (42)     | Population                         | Self-reports                                                                                 | Out-of-pocket medical expenses         |
| Verbrugge et al. (43)      | Population                         | Self-reports                                                                                 | Physical limitations, ADL, IADL        |

Note: HRQoL = health-related quality of life; ADL = activities of daily living; IADL = instrumental activities of daily living; NHP = Nottingham Health Profile; EORTC = European Organization for Research and Treatment on Cancer.

### Number of Diseases Included in Multimorbidity Indices

For the second research question, we analyzed the number of diseases included in each of the indices (Figure 4). The smallest index included four diseases (6), and the largest index with a defined list considered 102 different diseases (35). The mean number of conditions for all 39 multimorbidity indices was 18.5, and the median was 14 diseases. Overall, the range of the number diseases was rather small, with 87.2% of indices including between 6 and 25 chronic conditions.

### Type of Diseases Included in Multimorbidity Indices

Diabetes mellitus is the most frequent single diagnose listed in multimorbidity indices and is included in 38 out of 39 (97.4%) studies. Stroke, respectively cardiovascular diseases are considered in 35 indices (89.7%), followed by hypertension and cancer (each 84.6%), chronic obstructive pulmonary disease (COPD) (82.1%), and (osteo)arthritis (64.1%). The general term “heart disease” is listed in 22 studies (56.4%). Less than half of the indices include kidney diseases, heart failure, myocardial infarction, and depression. Other frequently listed diseases are presented in Figure 5.

### Study Population

The identified 18 weighted multimorbidity indices are used to provide an overview on the study populations and different methods to calculate weights. The majority of weighted indices (55.6%) are developed on the basis of hospital or geriatric patients, thus representing a very specific population. Four indices (22.2%) are based on data from the Health Maintenance

Organization (14), the health insurance Medicare (16), or veterans and war widows (10,46). Only four studies (22.2%) are using representative data from the general population.

Multimorbidity is mostly evident in older people. Accordingly, in many studies the analysis is restricted at minimum on age groups more than 50 years or older. Three indices are using data from people more than or equal to 70 years (10,12,49).

### Calculation of Weighted Multimorbidity Scores

Overall, three different approaches for the calculation of weights for single diseases can be distinguished. The first method is based on self-reported information. For each disease, the study participants are asked to specify the severity of disease (10,45,51). Other authors (17) assess the level of impairment caused by conditions by asking the respondents to report for each disease whether it interfered with their daily activities on a scale from one (“not at all”) to five (“a lot”). By calculating the mean self-reported burden for each disease, a final index is developed. For the calculation of the KoMO Score (48), the physicians rate the severity of diseases and the resulting functional limitations.

The most frequently used method is to empirically derive weights according to the individual impact of diseases on different outcomes. On the basis of complex regression models, weights are calculated either from hazard ratios, odds ratios, or regression coefficients. In six studies, each disease is weighted according to its individual mortality risk. One of the earliest instruments, the “Charlson Index” (11), used this method. It

Table 2. Overview on Weighted Multimorbidity Indices

| Author                    | Name of Weighted Index                      | Population                                                    | Data Sources                                   | Weighting Method                                                                     | Outcomes                                                       |
|---------------------------|---------------------------------------------|---------------------------------------------------------------|------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------|
| Bayliss et al. (14)       | —                                           | HMO members                                                   | Self-reports                                   | Self-reports: interference with daily activities                                     | Health status, physical functioning, depression, self-efficacy |
| Byles et al. (10)         | —                                           | Veterans, war widows                                          | Self-reports                                   | Self-reports: severity of disease<br>Calculation: mortality and hospital admission   | Mortality, hospital admission, HRQoL (SF-36)                   |
| Charlson et al. (11)      | Charlson Index                              | Hospital patients with breast cancer                          | Medical records                                | Calculation: mortality                                                               | Mortality                                                      |
| Crabtree et al. (45)      | Comorbidity Symptom Scale                   | Geriatric hospital patients                                   | Self-reports                                   | Self-reports: severity of disease                                                    | ADL (NEADL), health status, anxiety, and depression            |
| Fan et al. (46)           | Seattle Index of Comorbidity                | Enrolled patients in VA medical centers                       | Self-reports                                   | Calculation: mortality                                                               | Mortality, hospitalization                                     |
| George et al. (47)        | Medication-Based Disease Burden Index       | Hospital patients                                             | Medical records                                | Classification: weights according to DALYs from other study                          | Mortality, readmission                                         |
| Glattacker et al. (48)    | KoMo Score                                  | Rehabilitation patients with musculoskeletal diseases         | Self-reports/physician reports                 | Physician reports/self-reports: severity of disease and interference with activities | Health status, pain, ADL, mental health, coping                |
| Greenfield et al. (15)    | Index of Coexisting Diseases                | Hospital patients with hip replacement                        | Medical records, laboratory data               | Classification: severity of disease and physical impairment                          | Postoperative complications, ADL, IADL                         |
| Groll et al. (13)         | Functional Comorbidity Index                | Population, patients seeking spine ailment                    | Self-reports                                   | Calculation: physical functioning                                                    | HRQoL (SF-36)                                                  |
| Incalzi et al. (49)       | Incalzi Index                               | Medical and geriatric hospital patients                       | Medical records, laboratory data, self-reports | Calculation: mortality                                                               | Mortality                                                      |
| Kaplan and Feinstein (44) | Kaplan-Feinstein Index                      | Veterans, male hospital patients with diabetes                | Medical records                                | Classification: severity of disease                                                  | Mortality                                                      |
| McGee et al. (6)          | —                                           | Population                                                    | Self-reports                                   | Calculation: mortality                                                               | Prevalence, mortality                                          |
| Newmann et al. (16)       | Physiologic Index of Comorbidity            | Medicare enrollees                                            | Self-reports, clinical examination             | Classification: severity of disease                                                  | Mortality, mobility limitation, ADL                            |
| Rozzini et al. (50)       | Geriatric Index of Comorbidity              | Geriatric hospital and rehabilitation patients                | Self-reports/medical records                   | Classification: severity of disease                                                  | Mortality, functional disability                               |
| Sangha et al. (51)        | Self-Administered Comorbidity Questionnaire | Hospital patients                                             | Self-reports                                   | Self-reports: severity of disease                                                    | Hospitalization, acute inpatient charges, HRQoL (SF-36)        |
| Shwartz et al. (52)       | Shwartz Index                               | Hospital patients with one of eight common chronic conditions | Medical records                                | Calculation: patient costs                                                           | Patient costs                                                  |
| Tooth et al. (12)         | —                                           | Female population                                             | Self-reports                                   | Calculation: mortality, health service use, ADL, HRQoL (SF-36)                       | Mortality, health service use, ADL, HRQoL (SF-36)              |
| Von Korf et al. (53)      | Chronic Disease Score                       | Population                                                    | Administrative data                            | Classification: severity of disease                                                  | Mortality, hospitalization                                     |

Note: HRQoL = health-related quality of life; ADL = activities of daily living; IADL = instrumental activities of daily living; NEADL = Nottingham extended activities of daily living; VA = Veterans Affairs; HMO = health maintenance organization; DALY = disability adjusted life years.

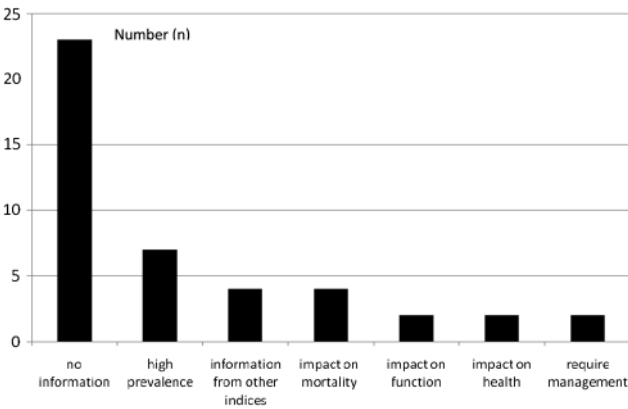


Figure 3. Overview on criteria for the selection of diseases.

was developed in the United States and includes 19 diseases, which are weighted according to the relative mortality risk within 1 year. Other studies assess the impact of chronic conditions on physical functioning (13), hospital admission (10), and patient costs (52) or derive different weights on the basis of a variety of outcomes, such as health service use, activities of daily living, or health-related quality of life (12).

A third method to apply weights is by defining specific criteria, such as the cholesterol level, which provide the basis for classifying diseases according to their level of severity. One example is the “Chronic Disease Score,” which derives information on the severity of diseases from the type of prescribed medicine, for example from patient records or health insurance data (53). More complex indices, such as the Index of Coexisting Disease, determine in two separate steps the severity of 13 chronic diseases and the resulting functional impairment (15).

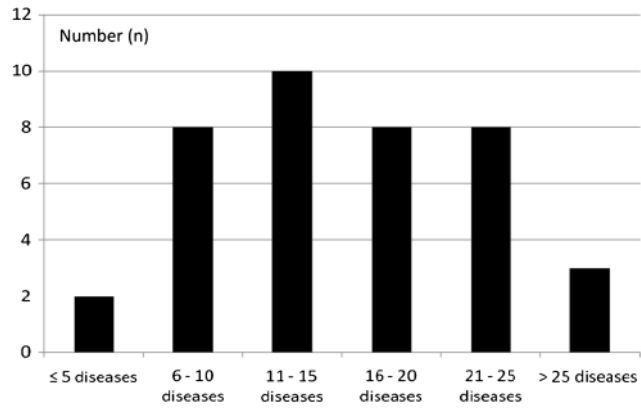


Figure 4. Overview on the number of diseases included in 39 multimorbidity indices.

### DISCUSSION

Overall, these results further emphasize the large heterogeneity of existing instruments for the assessment of multimorbidity. First of all, in less than half of all identified studies (41.0%), diseases are selected according to predefined criteria. These criteria include high disease prevalences in the general or study population on one end and a high risk for mortality, physical impairment, or health status on the other end. The majority of authors (58.3%) do not explain the selection procedure. This strongly suggests that pragmatic reasons, such as the availability of data, may determine the list of diseases.

As a result of the largely missing selection criteria, the quantity and type of included diseases are also very diverse. In 39 indices, the number of different conditions ranges from 4 to 102. This is partly caused by the use of different data sources. In medical records and administrative data,

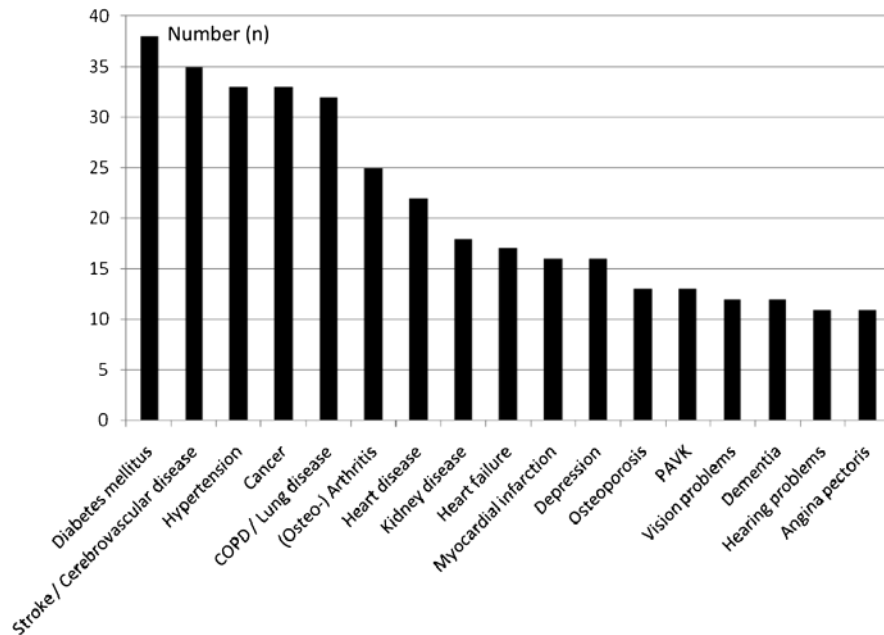


Figure 5. List of diseases, which are considered in 39 different multimorbidity indices.

the conditions are usually classified according to the International Classification of Disease (ICD). The ICD was developed to promote the comparability of morbidity and mortality statistics between different countries (54), thus including precise medical diagnoses from a professional perspective. In contrast to this, in interviews and questionnaires, self-reported diseases are labeled in order to be understandable and self-explanatory to the lay person.

In all data sources, different stages of disease abstraction, for example from the chapter to the four-character subcategory level in the ICD, further increase the variation in the number of conditions. For example, in some studies cancer is counted as one disease, whereas other authors distinguish between different types of malignant neoplasms and include them separately (49). The same applies for the general term “heart diseases,” which is used in a few indices to summarize different stages of heart conditions, such as arteriosclerosis, angina pectoris, and heart failure.

Thus, the systematic literature review also revealed the large range of diseases, which are included in 39 indices. Overall, we identified more than 150 different conditions accounting for multimorbidity. On the other hand, some conditions, such as diabetes mellitus, stroke, COPD, cancer, arthritis, and hypertension, are listed in nearly every multimorbidity analysis. Overall, the selection suggests that the focus of multimorbidity indices is primarily on diseases with a high prevalence in the population and with a severe impact on affected people.

Apart from these differences, indices without a specified list of conditions were not included in the review. An example is an original study on the impact of multimorbidity on physical functioning (7), which contained 185 different, but unspecified diseases. Because the lack of a list with single diagnosis is more frequent in larger indices, our findings on the number of diseases are not representative. This has to be kept in mind when looking at the validity of the results. Another example is the frequently used “Cumulative Illness Rating Scale,” which rates the severity of medical problems by different organ systems (55). The index was excluded from the literature review because single diagnoses are not specified.

Regarding the weighting methods for multimorbidity, we distinguished three different approaches. Empirically derived weights are primarily used to analyze the effects of multimorbidity on objective outcomes, such as mortality (11), costs (12), and hospitalization (46). The same applies for indices, where diseases are classified according to pre defined criteria, such as the prescribed medicine (53) or clinical parameters (16). Self-reported information of the severity of each conditions or its impact on daily activities (14) is mainly used for subjective outcomes, such as health-related quality of life (10) and depression (45). In view of the heterogeneous weighting methods, further research needs to be done to standardize weights for different outcomes.

In total, 79.5% of all data on multimorbidity is relying on self-reports of chronic diseases from interviews or questionnaire. The problem is that studies from the United States

show a rather poor agreement between data on chronic diseases obtained from self-reports and administrative records. For example, all studies, which assessed the correlation between the Charlson Comorbidity Index based on self-reports versus hospital documentation (56–58), report a rather weak concordance. Furthermore, the majority of weighted indices are developed on the basis of rather homogeneous populations, such as hospital and geriatric patients, at least more than or equal to 50 years (eg, 45,49). Thus, validity problems may arise when weights, which are derived from self-reports in older people, are transferred to studies, which analyze the impact of multimorbidity on the general population on the basis of administrative data.

The lack of an established multimorbidity index may be caused by several reasons. The first major reason is related to the inherent characteristics of indices. Their objective is to aggregate the complex reality into single indicators, such as a list of diseases. Although the selection of conditions can be justified, it is always an arbitrary process and thus prone to external criticism. Thus, it is not surprising that in the majority of the reviewed studies, a list of diseases was simply determined without further explanations.

The second major reason is the complexity of the phenomenon multimorbidity. It is even questionable, whether the current definition is over simplistic and inadequate, because the coexistence of two or more chronic conditions often represents the norm in older people (59), requiring the additional consideration of social, psychological, and emotional factors. In Germany, the National Advisory Council on the Assessment of Developments in the Health Care System (Sachverständigenrat zur Begutachtung der Entwicklung im Gesundheitswesen) has formulated a similar statement in its latest expertise. Concerning medical care of older multimorbid patients, the traditional disease-oriented approach should be replaced by a focus on improving functional capabilities and quality of life (60). Therefore, from a more holistic perspective, the assessment of multimorbidity by using a simple list of (weighted) diseases may be not sufficient. Additionally, social networks and support, coping strategies, individual preferences, and living conditions have to be considered in the assessment of multimorbidity. This has partly been achieved by incorporating the severity of diseases in indices. Additionally, in interviews and questionnaires, a general question on the extent of social, mental, and physical impairment, which is caused by the sum of diseases, can be included.

Beyond this, the level of accuracy of disease labeling has to be determined, which has significant influence on the number of conditions included in an index. A recommendation is to use disease specifications that can be distinguished by lay persons. This increases the validity of self-reported conditions.

Another challenge is how to deal with diseases, which are directly caused by other pathological conditions. For example, is blindness as a consequence of diabetes counted as an independent diagnosis? In this case, the understanding of

laypersons on the distinction of diseases can also serve as a point of reference.

In addition to these inherent problems, some methodological challenges have to be overcome concerning the establishment of a standardized instrument. First of all, criteria for the selection of diseases that account for multimorbidity have to be defined. They can be extracted from the literature review and from the widely accepted definition of multimorbidity (4), which accentuates the attribute chronic. In the German and Dutch health care systems for example (61,62), chronic diseases are characterized by (a) their long duration, (b) their need for continuous medical treatment, and (c) their severe impact on affected people. Furthermore, they have (d) to be highly prevalent in the older population in order to restrict multimorbidity indices on diseases with certain relevance in the health care system and society. These criteria provide a good basis for the selection of diseases.

In order to identify relevant diseases, which fulfill the previously specified criteria, the German statutory health insurances provide representative data on the most frequent diagnoses in the in- and outpatient sector. In addition to this, mortality statistics are publicly available (64). All data sources are coded according to the standardized ICD-10 and can be stratified for different age groups, thus providing specific information for older people. Diseases, which were among the 20 most frequently listed diagnoses for people more than or equal to 65 years in these three data sources, were cancer, diabetes mellitus, depression, hypertension, myocardial infarction, chronic ischemic heart disease, heart arrhythmias, heart insufficiency, stroke, COPD, and arthritis.

Future multimorbidity indices should at least include these 11 diagnoses. This applies primarily for studies based on administrative data, which also rely on the ICD-10. For self-reported diseases from questionnaires and interviews, related cardiovascular conditions such as chronic ischemic heart disease and myocardial infarction can be grouped together for nonmedical study participants. For both approaches, there is always a possibility of adding other relevant or study-specific diseases.

Overall, mean weights for different outcomes should be calculated on the basis of several representative populations in order to increase the validity of the results. So far, the development of weighted multimorbidity indices has primarily been based on single and very specific populations.

The systematic literature review pointed out the heterogeneity of existing indices and the need for a new, established instrument to assess multimorbidity. This is even more important in view of the growing number of older people, who will dominate health research in the next decades.

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## APPENDIX I

List of Diseases in Multimorbidity Indices Measuring the Association Between Multimorbidity and Different Health Outcomes

| Author                    | Diseases                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bayliss et al. (14)       | Angina/coronary artery disease, asthma, back pain, bronchitis, chronic/COPD, cancer (within the past 5 years), cholesterol, elevated, colon problem (diverticulitis, irritable bowel), congestive heart failure, diabetes, hard of hearing, hypertension, kidney disease, nerve condition, osteoarthritis, osteoporosis, overweight, poor circulation (peripheral vascular diseases), rheumatic disease, other, rheumatoid arthritis, stomach problem (gastritis, peptic disease), stroke, thyroid disorder, vision problem                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Byles et al. (10)         | Angina or chest pain, arthritis, rheumatism, blood pressure, cancer, chronic allergic or sinus problems, chronic lung disease, chronic pain, depression, dermatitis or other chronic skin condition, diabetes, digestion problems, fits, faints, funny turns, forgetfulness, gall bladder trouble, hearing problems, heart attack, heart bypass, heart failure, kidney problems, liver problems, muscle weakness or spasm, back or spinal problems, sciatica, back or spinal problems, stroke, urinary tract problems, vision problems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Charlson et al. (11)      | Aids, any tumor, cerebrovascular disease, chronic pulmonary disease, congestive heart failure, connective tissue disease, dementia, diabetes, diabetes with end organ damage, hemiplegia, leukemia, lymphoma, metastatic solid tumor, mild liver disease, moderate or severe renal disease, myocardial infarction, peripheral vascular disease, ulcer disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Crabtree et al. (45)      | Angina, anxiety and depression, arthritis/osteoporosis, breathlessness secondary to cardiovascular cause, breathlessness/wheeze secondary to respiratory cause, cerebrovascular disease, constipation, cough/sputum secondary to COPD/asthma, diabetes, diarrhea, epilepsy, hearing problems, Parkinson's disease, pain, peripheral vascular disease, side effects from medications, skin disease, unsteadiness, falls and syncope, upper gastrointestinal symptoms, urinary problems, visual problems, walking and mobility                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Fan et al. (46)           | Arthritis, cancer, cardiac disease variables (angina, any heart disease, coronary artery bypass graft surgery or percutaneous trans catheter coronary angioplasty, coronary artery disease, prior myocardial infarction), congestive heart failure, depression, diabetes, drug abuse, enlarged prostate, heartburn, hypertension, human immunodeficiency virus disease, liver disease, lung disease, osteoporosis, posttraumatic stress disorder, renal insufficiency, seizure, stroke, thyroid disease, ulcer disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| George et al. (47)        | Alzheimer's disease and other dementia, asthma, Benign prostatic hypertrophy, cerebrovascular disease, cirrhosis of the liver, COPD, diabetes mellitus, epilepsy, hepatitis B, hepatitis C, human immunodeficiency virus /acquired immunodeficiency syndrome, hypertensive heart disease, ischemic heart disease, malignant neoplasms, nephritis/nephrosis, Parkinson's disease, peptic ulcer disease, rheumatic heart disease, skin disease, tuberculosis                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Glattacker et al. (48)    | Cancer, coronary heart disease, dementia, depression anxiety, diabetes, diseases of the liver and gall bladder, diseases of the respiratory systems, gastrointestinal diseases, hypertension, musculoskeletal diseases, myocardial infarction (in the past), neurological diseases (stroke), peripheral vascular diseases, renal diseases                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Greenfield et al. (15)    | Cerebral vascular accident, congestive heart failure (no known ischemic heart disease), diabetes mellitus, hepatobiliary disease, gastrointestinal disease, hypertension, ischemic heart disease, malignancies (excluding basal cell carcinoma of the skin), organic heart disease, peripheral vascular disease, primary arrhythmias and conduction problems, renal disease, respiratory problems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Groll et al. (13)         | Anemia, angina, anxiety, arthritis, asthma, back pain, bowel disease, cancer, congestive heart failure, COPD, depression, dementia, diabetes, hearing impairment, hypertension, kidney disease, liver disease, myocardial infarction, migraine, neurologic disease, osteoporosis, peripheral vascular disease, stroke/transient ischemic attack, upper gastrointestinal disease, visual impairment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Incalzi et al. (49)       | Acute leukemia, acute pancreatitis, anemia (Hb < 10 mg/dl), aplastic anemia (transfusion at intervals > 20 days), aplastic anaemia (transfusion at intervals ≤ 20 days), chronic active hepatitis/cirrhosis, chronic lymphocytic leukemia (stage A-B), chronic lymphocytic leukemia (stage C), chronic myelogenous leukemia (early stage), chronic myelogenous leukemia (blast crisis), chronic obstructive pulmonary disease, chronic respiratory failure, stage I (hypoxemia), chronic respiratory failure, stage 2-3 (hypoxemia and hypercapnia), Chron's disease, ulcerative colitis, collagenosis with organ damage, congestive heart failure (NYHA I-II), congestive heart failure (NYHA III-IV), decubitus ulcers, stage 3, dementia (without anorexia, akinesia, dysphagia, decubitus ulcers), dementia (with decubitus ulcer, anorexia, akinesia, dysphagia), diabetes mellitus, diabetes mellitus with organ damage, Hodgkin's disease, stage I-II, Hodgkin's disease, stage III, hypertension, hyperthyroidism, infectious endocarditis, ischemic stroke, liver steatosis, mild liver disease, meningitis and encephalitis, mild renal failure (creatinine < 2.5 mg/dl), multiple myeloma, stage I, multiple myeloma, stage III, multiple sclerosis, myasthenia gravis (early disease), neoplastic metastatic disease, non-Hodgkin lymphomas, parenchymatous brain haemorrhages, Parkinson's disease (with decubitus ulcers, anorexia, akinesia, dysphagia), peptic ulcer disease, peripheral arterial disease, peritoneal carcinosis, previous pulmonary embolism, pulmonary thromboembolism, sepsis, severe renal failure (creatinine > 2.5 mg/dl), transient ischemic attack, tumor (localized disease) |
| Kaplan and Feinstein (44) | Alcoholism, cardiac, cerebral or psychic, gastrointestinal, hepatic, hypertension, locomotor impairment (regardless of cause), malignancy, miscellaneous, peripheral vascular, renal, respiratory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| McGee et al. (6)          | Coronary heart disease, cerebrovascular accident, stroke, diabetes, hypertension                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Newmann et al. (16)       | Arthritis, cerebrovascular disease, chronic obstructive lung disease, coronary heart disease, depression (CES-D > 10), diabetes, kidney disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Rozzini et al. (50)       | Anemia, heart disease (non-ischemic/organic), musculoskeletal diseases, parkinsonism, peripheral vascular disease, renal diseases, stroke                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| Sangha et al. (51)        | Anemia or other blood disease, back pain, cancer, depression, diabetes, heart disease, high blood pressure, kidney disease, liver disease, lung disease, other medical problems, osteoarthritis, degenerative arthritis, rheumatoid arthritis, ulcer or stomach disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Shwartz et al. (52)       | Acute and chronic bronchitis and asthma, acute myocardial infarction, cerebrovascular disease, coronary artery disease without acute myocardial infarction, hip and femur fracture, prostate disease, respiratory malignancy, spine and back disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Tooth et al. (12)         | Alzheimer's disease, anxiety, arthritis, asthma, bronchitis/emphysema, chest pain, diabetes, fall caused serious injuries, fall (fractures), fall (medical attention), heart disease, hypertension, low iron, other cancers, osteoporosis, skin cancers, stroke, urinary incontinence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Von Korff et al. (53)     | Acne, asthma, rheumatism, Asthma, rhinitis, cancer, diabetes, epilepsy, glaucoma, gout, hyperuricemia, heart disease, high cholesterol, hypertension, migraines, Parkinson's, respiratory illness, rheumatoid arthritis, tuberculosis, ulcers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

## APPENDIX II

## List of Diseases in Weighted Multimorbidity Indices

| Author                     | Diseases                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CDC (24)                   | Cancer (except nonmelanoma skin cancer), cataracts, diabetes, heart disease, hypertension, osteoporosis/hip fracture, stroke, varicose veins                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Cesari et al. (25)         | Cancer, cerebrovascular heart disease, congestive heart failure, coronary heart disease, dementia, depression, diabetes, hypertension, lung disease, obesity, osteoarthritis, Parkinson's disease, peripheral artery disease, renal failure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Fillenbaum et al. (26)     | Cancer (excluding skin cancer), cerebrovascular heart disease, coronary heart disease, diabetes, hypertension                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Forman-Hoffman et al. (27) | Arthritis, cancer, diabetes, heart disease, hypertension, lung disease, psychological problems, stroke                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Forrest et al. (28)        | Angina, any cancer, arthritis (including osteoarthritis and rheumatoid arthritis), cataract, depression, diabetes, falls/fractures, glaucoma, hypertension, hyperthyroid disease, hypothyroid disease, macular degeneration, memory problems, muscle pain, myocardial infarction, osteoporosis, Parkinson's disease, poor hearing, poor vision, seizures, stroke                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Fried et al. (29)          | Angina, arthritis, cancer, congestive heart failure, diabetes, hearing problems, high blood pressure, hip fracture, lung disease, myocardial infarction, other heart disease, Parkinson's disease, stroke, vision problems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Fuchs et al. (30)          | Anemia, arthritis or rheumatism, circulatory disease, diabetes, gastrointestinal diseases, heart attack, heart diseases (other than heart attack), hip fracture, hypertension, osteoporosis, Parkinson's disease, respiratory diseases, stroke, urinary tract or kidney disease                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Fung et al. (31)           | Alcohol misuse, benign prostatic hyperplasia, cancer, cataracts, chronic headaches, chronic obstructive lung disease, coronary artery disease, depression or other mental health condition, diabetes, heart failure, hyperlipidemia, hypertension, obesity, osteoarthritis, symptomatic asthma, uterine bleeding                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Grimby and Svanborg (32)   | Anginal pain, back pain, cancer, claudication, diabetes, hearing impairment, hip joint disorders, hypertension, knee joint disorders, lung disease, mental disorders, myocardial infarction, stroke/paresis, upper extremities disorders, urinary incontinence, visual impairment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| Guralnik et al. (33)       | Arthritis, cancer (except non-melanoma skin cancer), cataracts, diabetes, heart disease, hypertension, osteoporosis or hip fracture, stroke, varicose veins                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Higashi et al. (34)        | Atrial fibrillation, asthma, benign prostatic hypertrophy, breast cancer, chronic obstructive pulmonary disease, colorectal cancer, coronary artery disease, dementia, depression, diabetes mellitus, dyspepsia, heart failure, hypertension, osteoarthritis, osteoporosis, pressure ulcer, prostate cancer, renal insufficiency, stroke, urinary incontinence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Holman et al. (35)         | Infectious or parasitic diseases (Candidiasis, HIV or AIDS, other extrapyramidal disease, septicemia, systemic mycosis, tuberculosis) Neoplasms (benign neoplasms of the colon or rectum, breast cancer, lung cancer, lymphoma or leukemia, other primary cancer, secondary cancer of lymph nodes, uterine leiomyoma), endocrine, metabolic, or immune diseases (avitaminosis, complications of diabetes, diabetes mellitus, fluid or electrolyte disorders, gout, hypothyroidism, immune system disorders, malnutrition or cachexia, obesity, other metabolic disorders), blood disorders (anemias, coagulopathies), mental disorders (affective psychosis, alcoholism, dementia or senility, illicit drug use, incontinence, mental retardation, neuroses or personality disorders, nonpsychotic depression, other nontransient psychoses, schizophrenia), diseases of the nervous system of sense organs (blindness and low vision, cataract, degenerative neurologic or muscular diseases, epilepsy, glaucoma, infantile cerebral palsy, inflammatory central nervous system diseases, other extrapyramidal disease, paraplegia or quadriplegia, Parkinson's disease), diseases of the circulatory system (cardiac dysrhythmias or arrest, cerebrovascular disease or stroke, chronic pulmonary circulatory disorders, congestive cardiac failure, hemorrhoids, hypertension, myocardial infarction, other ischemic heart disease, peripheral vascular disease, valvular disease), diseases of the respiratory system (asthma, chronic pulmonary disease, gastritis or duodenitis, gastrointestinal hemorrhage, noninfectious digestive disorders, esophageal system (abdominal hernia, cholelithiasis and cholecystitis, chronic liver disease, diverticular disease, gastric or duodenal ulcers, hemorrhoids, hypertension, myocardial infarction, other ischemic heart diseases, other diseases of intestine, peptic ulcer, peritoneal adhesions, sequelae of chronic liver disease), diseases of the genitourinary system (Benign prostatic hypertrophy, breast disorders, cervicitis or vaginitis, chronic renal disease, female infertility, genital prolapse, gynecologic pain, menopausal disorders, menstrual disorders, noninflammatory ovarian conditions, other kidney, ureter, or bladder conditions, pelvic inflammatory disease, urinary tract infection, uterine disorders), pregnancy, childbirth, and the puerperium (all except normal delivery), diseases of skin of subcutaneous tissue (chronic skin ulcer), diseases of the musculoskeletal system and connective tissue (dorsopathies, other arthropathies or joint disorders, osteoporosis, rheumatologic diseases), congenital anomalies, symptoms, signs, and ill-defined conditions (abdominal pain, migraine and headache, nausea and vomiting, symptoms concerning nutrition, metabolism and development, symptoms involving alteration-consciousness, syncope, collapse, the cardiovascular system, respiratory system, chest, and cyanosis), any injury or poisoning (late effects of injuries), factors influencing health status and contact with health services (potential health hazards related to communicable diseases, housing, household, economic, family, or other psychosocial circumstances) |
| Hudon et al. (36)          | Allergies, anemia, anxiety, arthritis, back disease, cancer, cardiac disease, cognitive deficit, depression, dermatologic disease, diabetes, epilepsy, frequent headache, hypertension, mental deficiency, obesity, ocular disease, psychosis, pulmonary condition, renal disease, serious articular, muscular or tendinous condition, stroke sequelae, thyroid disease, ulcer, or other gastric problems                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Marengoni et al. (17)      | Anaemia, anxiety, arthritis, atrial fibrillation, cerebrovascular diseases, chronic obstructive pulmonary disease, coronary heart disease, dementia, diabetes, epilepsy, heart failure, hip fractures, hypertension, major depression, malignancy, obesity, Parkinson disease, peripheral neuritis, rheumatic arthritis, valvular heart diseases, visual impairment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Menotti et al. (37)        | Angina pectoris, cancer, chronic obstructive pulmonary disease, diabetes mellitus, heart failure, intermittent claudication, myocardial infarction, stroke, transient cerebral ischemic attack                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Merikangas et al. (38)     | Cancer, cardiovascular problems (heart attack, hypertension, other heart disease, stroke), diabetes mellitus, digestive problems (irritable bowel syndrome, ulcer), musculoskeletal problems (arthritis, chronic back/neck pain), respiratory problems (allergies, asthma, chronic obstructive pulmonary disease), sensory organ impairment (hearing impairment, vision impairment)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| Michelson (39)             | Allergies, angina, arthritis, asthma, blood pressure, cancer, cardiac infarction, diabetes, hearing impairment, long-standing medication, redlimb function, skin problems, visual impairment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Min LC (2007) (40)         | Atrial fibrillation, chronic obstructive lung disease, chronic obstructive pulmonary disease, chronic renal failure, coronary artery disease, dementia, depression, diabetes mellitus, hearing loss, heart failure, hypertension, osteoarthritis, osteoporosis, pressure ulcers, stroke, urinary incontinence                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Patel et al. (41)          | Arthritis, bone fracture, cancer, diabetes, heart, respiratory illness, stroke                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Schoenberg et al. (42)     | Arthritis, cancer, diabetes, heart conditions, high blood pressure, lung disease, psychiatric problems including emotional or nervous conditions, stroke                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Verbrugge et al. (43)      | Atherosclerosis, arthritis, cancer (=all except nonmelanoma skin), cerebrovascular disease, diabetes, fracture of hip, high blood pressure, hearing impairment, ischemic heart disease, other circulatory system condition (=phlebitis, varicose veins), osteoporosis, vision disease (=cataract, glaucoma, disease of retina), visual impairment                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |