BMJ Open

How to extend value-based healthcare to population-based healthcare systems? Defining an outcome-based segmentation model for health authority

Paulus Torkki ,[1] Riikka-Leena Leskelä,[1,2] Pirjo Mustonen,[3] Miika Linna,[4,5] Paul Lillrank[4]

To cite: Torkki P, Leskelä R-L, Mustonen P, *et al*. How to extend value-based healthcare to population-based healthcare systems? Defining an outcome-based segmentation model for health authority. *BMJ Open* 2023;**13**:e077250. doi:10.1136/bmjopen-2023-077250

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2023-077250).

PT and R-LL contributed equally.

PT and R-LL are joint first authors.

Received 22 July 2023
Accepted 18 October 2023

For numbered affiliations see end of article.

Correspondence to
Dr Paulus Torkki; paulus.torkki@helsinki.fi and Ms Riikka-Leena Leskelä; riikka-leena.leskela@nhg.fi

ABSTRACT

Objectives Value-based healthcare (VBHC) is considered the most promising guiding principle for a new generation of health service production. Many countries have attempted to apply VBHC to managerial and clinical decision-making. However, implementation remains in its infancy and varies between countries. The objective of the study is to help health systems implement a value-based approach by building an outcome-based population segmentation model for health authorities (HAs).

Design First, we define the principles according to which segmentation models in healthcare could be developed. Second, we merge the theoretical characteristics of outcomes with population segmentation dimensions identified in previous literature and design a flow model that establishes population segments from these combinations. We then estimate the size of the segments based on national register data.

Results The population can be divided into 10 different segments based on relevant outcomes, goals and the outcome measurement logic. These segments consist of healthy, help, increased risk, mild curable without risk, mild curable with risk, severe curable without risk, severe curable with risk, single chronic, multimorbid and terminal. The representatives of Finnish HAs found the segments meaningful for evaluating and managing the healthcare system towards improved population health.

Conclusions An outcome-based segmentation model for the entire population is needed if an HA wants to steer the healthcare system employing the principles of VBHC. Segmentation should be based on the outcome measurement logic and outcome measurements relevant to each segment and the number of segments has to be limited.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The logic of the segmentation model was tested by quantifying the size of the segment.
⇒ The model was validated in a workshop by health authorities and ministry representatives.
⇒ The testing of the model is limited to the quantification of segments, and the use of the model in steering requires further research.

BACKGROUND

Value-based healthcare (VBHC) is considered the most promising guiding principle for a new generation of health services. Value in healthcare is defined as patient-relevant outcomes per patient-level cost. Thus, a VBHC-based system would shift focus from outputs to outcomes.[1 2] There are many attempts worldwide to apply VBHC to managerial and clinical decision-making, resource allocation, reimbursement schemes and performance measurement. However, implementation remains in its infancy, varying between countries.[3]

VBHC originally focused on health service production rather than the health of a population or the performance of a healthcare system. Despite the evident interest in VBHC as a management trend in healthcare organisations, there has been limited research on how VBHC has been adopted at the policy level.[4 5] According to Mjåset *et al*,[3] the VBHC framework functions better in some healthcare systems than others. At the system governance level, VBHC has been focusing on incentivising providers.[6]

VBHC best applies to medical conditions for which a clear diagnosis and a corresponding curative process with a definitive endpoint and outcomes exist.[2] The question remains how VBHC can be employed for long-term, chronic and multimorbid cases, the primary concern of public health. On average, 33% of the population in different countries has multiple chronic conditions.[7]

We use the term health authority (HA) to refer to an organisation responsible for making health services available to a predefined population. HAs have an interest not only in the value (the costs and outcomes) of services for specific diseases but also in

the current and future health of populations. In addition to minimising health disparities, the goals of HAs parallel those of VBHC: to maximise health given specific budget allocations. Value is defined as outcomes per cost. However, the calculation of costs is done following a similar logic for any segment, that is, by summing over the costs of all members of the segment over a specified time period. Therefore, in this study, we focus on the outcomes, which are different for different diseases and patient groups.

Applying VBHC at the level of an HA requires understanding how outcomes should be defined and measured and how outcomes should be used to develop and manage health services. Given that an HA covers an entire population, managing the health of a population requires dividing it into meaningful segments. VBHC has followed the logic of measuring outcomes per diagnosis group.[2] However, the approach of segmenting based on standard sets developed by the International Consortium for Health Outcomes Measurement (ICHOM, www.ichom.org) is problematic at the population level since, first, it divides the population into numerous segments; second, multimorbid cases have not been taken into account; third, the segments are not mutually exclusive and fourth, the standard set groups do not cover the whole population.

Traditionally, segmentation in healthcare has relied on urgency and severity, clinical categories based on organ systems and diseases or diagnostic groups, principal methods, specialisation level and demographic categories.[8–10] Segmentation models can be divided into expert-based tools and data-driven tools.[11–14] We further analysed the results of the systematic review of Chong *et al*[11] adding the model developed by Brommels[15] to find out potential segmentation models for VBHC at a population level (table 1). Our criteria for the segmentation models were that they cover the whole population and that the segments can be defined ex ante, that is, they are prescriptive. The selected models were analysed based on whether they follow a value-based logic (VBL), whether the segments are mutually exclusive and whether the model is published in a peer-reviewed journal.

The selected segmentation models are quite close to each other, but none of them fulfil the criteria for value-based or outcome-based segmentation. Some of them are inconsistent, separating, for example, elderly care or maternity care. The most problematic issue is that the models follow the VBL only limitedly. The criteria for the VBL were (1) the individuals within each segment must have sufficiently similar expected outcomes measurable in a similar way and (2) each segment must be sufficiently different in terms of outcome goals or measurement logic to justify separate consideration. Sufficient similarity is defined in terms of being able to create one indicator to describe the key outcome of the segment. The explanation may be that the objectives of the previous models[12 14–17] vary from need-based modelling to the segmentation of care services and thus the objectives differ from VBL. Our objective is to develop an outcome-based population segmentation model for HAs, demonstrate the volume of each segment using register data and discuss how an HA can use the model.

METHODS

Our methodology follows the principles of design science,[18] which focuses on creating methods and tools to solve practical problems. We combine a top-down, purpose-driven approach with verification through a bottom-up, empirical validation (figure 1).

In the selection of segmentation variables and the development of the segmentation model, we used a methodology similar to Lillrank *et al*.[14] First, the objective of segmentation was defined; second, the segmenting variables were selected and defined; third, the variables were cross-checked for combinations and overlap and, finally, the key questions by which segments are identified were expressed as a flow model.

The segmentation model was tested in an expert workshop in June 2019, with invitations sent to the management and development personnel from regional HAs in Finland. In total, 50 participants were divided into six groups, in which participants commented on and developed the segmentation model and outcome goals for each segment.

Once the segments were developed based on the selected dimensions, the volume estimates for each segment were calculated. As a case example, we calculated the volumes (proportions) of the segments in the adult (aged 18 and above) population of Finland (4.4 million people) based on national register data from 2018. Finland has a unique Social Security ID as well as national registries for healthcare services, which enables combining individual-level information between registries to assess reliable population-level analysis. The estimates were based on individual-level data from the national healthcare registers and cause of death registers (The Finnish Institute of Health and Welfare, Statistics Finland). The national healthcare registers included Hilmo and Avohilmo, which include all outpatient visits and inpatient episodes for all public HAs in Finland. The registers include diagnoses for every contact and that information was used to classify the patients into segments.

Two additional workshops were held in October 2019 with the management personnel of two Finnish HAs (Keski-Suomi and Pirkanmaa regions). Groups consisted of 10–15 individuals, including chief medical officers, directors of nursing, directors of health services and administrative staff members. The purpose of the workshops was to assess the face validity of the segmentation model. The segments were finalised based on the workshops.

Availability of data and materials

The data generated and analysed during this study is available from the corresponding author on request. The

Table 1 Population-level segmentation models

Segmentation model	Segmentation principle	Segments	Value-based logic	Mutually exclusive segments	Peer-review publication
Lynn *et al* (2007)	(1) The set of population segments must be limited if the healthcare system is to offer a sensible array of integrated services for each segment and to make those services available almost everywhere. (2) The set of population segments should include everyone; that is, at every point in his or her life, every person should fit into one of these categories. (3) The people in each population segment must have sufficiently similar healthcare needs, rhythms of needs and priorities to make the segment useful for planning, but each segment must be different enough to justify separate consideration. Planners must be able to structure the supports, service arrays and care delivery arrangements so that they will meet the needs of anyone in that segment reasonably well, even though they may be mismatched to other segments.	Healthy, maternal and infant health, acutely ill, chronic conditions, normal functions stable, but serious disability, short period of decline before dying, limited reserve and exacerbations, frailty, with or without dementia	Limitedly	No	Yes
Vuik *et al* (2016b)	Clustering analyses based on care utilisation	Very low use, low primary care, high emergency care, specialist care, high primary care, very high needs, emergency high needs, low emergency high needs, home care	No	Yes (cannot be defined ex ante)	Yes
Brommels (2020)	(1) The production logic of the professional service is related to how well the health problem is structured and supported by specific medical knowledge; (2) the service distribution channel (service distributed in physical proximity or at a distance using e-health tools) and (3) the capability and interest of patients to self-manage their health and disease.	Healthy persons, persons with incidental needs, persons with chronic conditions, persons with multiple health problems and illnesses, persons needing precise elective interventions, persons needing qualified accident and emergency services and tertiary care patients	Limitedly	No	Yes
Adjusted clinical groups	Age, sex and all medical diagnoses	Hierarchical logic: 264 expanded diagnostic clusters, 27 major expanded diagnosis clusters and six resource utilisation bands: non-users, healthy users, low morbidity, moderate morbidity, high morbidity and very high morbidity	No	Yes	Yes

Continued

Table 1 Continued

Segmentation model	Segmentation principle	Segments	Value-based logic	Mutually exclusive segments	Peer-review publication
Clinical research groups	Clinical and demographical characteristics	Non-users healthy/non-user (concurrent), healthy/non-user (prospective), significant acute (concurrent), significant acute (prospective), single minor chronic, multiple minor chronic, single dominant or moderate chronic, dominant or moderate chronic, pair dominant/moderate chronic, triplets malignancy under active treatment catastrophic	No	Yes	Yes
Lombardy	(1) The set of population segments must be limited. (2) The set of segments must include everyone, so that at every point in his/her life, every person fits into only one segment. (3) When a subject meets the criteria for several segments, he is assigned to the first segment in the order established. (4) Individuals in each segment must have similar healthcare needs and priorities to make the segment useful for planning, but each segment must be different enough to justify separate considerations.	Maternity, infancy, elderly, one CD, several CDs, possible CD, acute event, healthy and unknown	Limitedly	No	Yes
British Columbia Health System Matrix	(1)'The set of population segments must be limited if the healthcare system is to offer a sensible array of integrated services for each segment and to make those services available almost everywhere. (2) The set of population segments should include everyone, that is, at every point in his or her life, every person should fit into one of these categories. (3) The people in each population segment must have sufficiently similar healthcare needs, rhythms of needs and priorities to make the segment useful for planning, but each segment must be different enough to justify separate consideration.	End of life, frail in care (in residential care), cancer, frail with high complex chronic conditions (HCC), high complex chronic conditions (without HCC), frail in the community, maternity and healthy newborns, mental health and substance use, medium complex chronic conditions, low complex chronic conditions, child and youth major <18 years, adult major age 18+, healthy non-user	Limitedly	No	No

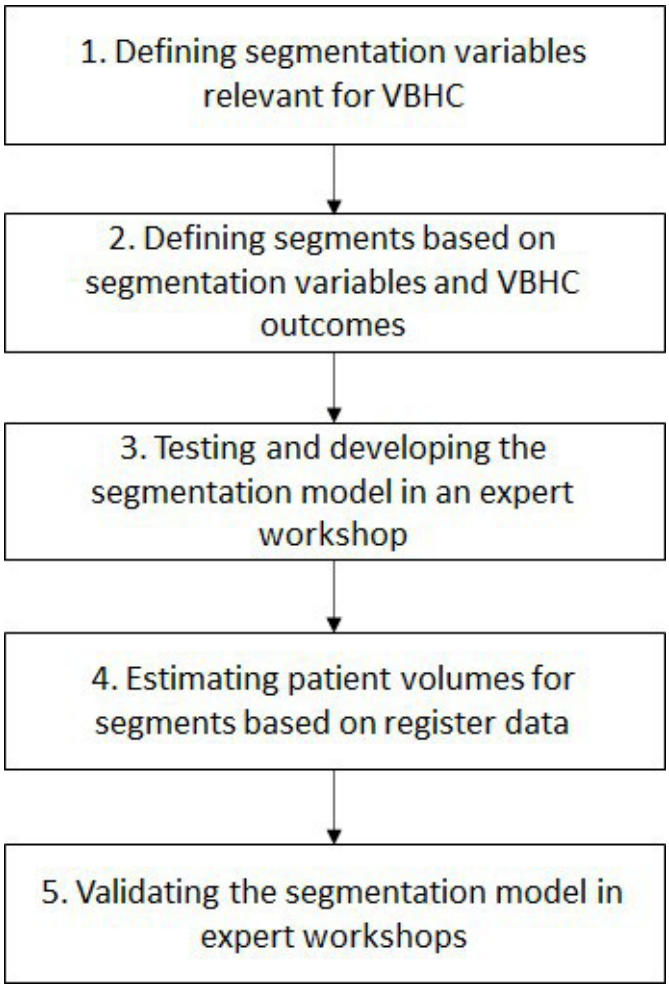

Figure 1 The process of this study. VBHC, value-based healthcare.

data from national registers used to calculate the proportions of the segments is at the individual patient level and requires a research permit to be accessed.

Patient and public involvement

No patient involved.

Dimensions of segmentation in healthcare

Segmentation as a systematic methodology emerged within marketing during the post-World War II expansion of markets and consumer choices.[19] In earlier studies,[12 14–17] the following patient-related segmentation dimensions have been used: health status, health-related risk, capabilities, multimorbidity, severity and urgency. These dimensions and their relevance must be considered from the VBHC point of view. Supply-based dimensions, such as clinical methods, are irrelevant in population-level segmentation.

Health status

Traditionally, the WHO has defined health as a 'state of complete physical, mental and social well-being and not merely the absence of disease or infirmity'. Huber and colleagues[20] proposed a new definition of health as the ability to adapt and self-manage in the face of social, physical and emotional challenges.

Health status can range from healthy to a terminal condition, with intermediate categories being curable and chronic conditions.[9]

Health status can be viewed as the basis of outcome-based segmentation since the primary focus of VBHC is the outcome, typically measured as a change in one's health status.[1] In addition, the number of simultaneous conditions (ie, multimorbidity) is essential to evaluate. Multimorbidity is the presence of several diseases or conditions, often with a cut-off of two or more.[21] Multimorbidity is relevant to discern from single chronic conditions because VBHC can be applied to single conditions, but the value in multimorbid conditions requires a different measurement logic.[2]

Health-related risks

Among others, a sedentary lifestyle, obesity and tobacco use are strongly associated with a variety of long-term adverse health outcomes.[22 23] When making resource allocation decisions, healthcare delivery organisations must assess modifiable health risks.[24] For an HA, understanding the population segment with increased health risks is relevant from the viewpoint of prevention and, therefore, should be included in the adapted outcome-based model. Health-related risks can be defined as high blood pressure, tobacco use, high blood glucose, physical inactivity and overweight and obesity, as they are the leading global risks for mortality based on WHO.

Capabilities

The capabilities of the population are related to health-seeking behaviour and how individuals engage in the cocreation of health. Capabilities represent combinations of knowledge (health literacy) and motivation (willingness to cocreate).[25]

The capabilities of the individual must be considered in service provision since they reflect the patient's ability for self-care and willingness to engage in the cocreation of services. However, they do not affect the outcome goals or measurement logic and, therefore, we do not include them in the outcome-based segmentation model.

Severity and urgency

Severity and urgency are key elements in many segmentation models.[8–10] Severity refers to the extent of damage or harm resulting from an incident or state if nothing is done. Urgency refers to the severity of an outcome as a function of waiting time.

Urgency is one of the most relevant factors in planning the health service provision. However, to evaluate outcomes, no clear distinction is made between urgent and nonurgent conditions; the expected outcomes can be similar regardless of urgency. Also, many pathways may begin with an urgent need but then evolve similarly to nonurgent pathways. As an example, a curable trauma is initially urgent, but the outcome measurement logic

is similar to conditions cured through elective surgery. Therefore, we do not include urgency in the first layer of the segmentation model. Severity is essential to consider, however, since the expected outcomes and measurement logic differ significantly between minor and major cases.

Designing the segmentation model

Segmentation is completed for a defined purpose and specific goals. The purpose of our segmentation model is to support HA in value-based management at the population level. For an HA, the goals consist of promoting the health of a population and minimising health disparities.[26–28] In VBHC, the goal is to maximise value for patients, whereby value is defined as patient-relevant health outcomes achieved over a full cycle of care per dollar spent.[1] Combining these goals with the general segmentation principles, we define the primary criteria of outcome-based segmentation as follows:

- Segmentation must be relevant in terms of managing health outcomes at the population level.
- The individuals within each segment must have sufficiently similar expected outcomes that are measurable in a similar way.
- Each segment must be sufficiently different in terms of outcome goals or measurement logic to justify separate consideration.
- The identified population segments should include everyone; every person at every point in their life should fit into one of these categories.

The goals of VBHC and HAs align to maximise the health of a population within a given budget. Thus, segmentation must begin with the health goals of the population, and the health status of a population is the most relevant segmentation dimension.

RESULTS

The health statuses are described in terms of the number of health conditions, the severity of the condition and health behaviour-associated risks. These dimensions affect the goals of the patient groups and are thus important for an HA to consider.

The health statuses are first categorised by severity. Healthy people cannot have a severe condition, while terminal cases are always severe. Curable conditions can be separated into mild and severe cases. Care processes for severe, curable conditions follow a disease-specific logic, and outcomes can be measured with disease-specific metrics, such as those provided in the ICHOM standard sets. For mild, curable conditions (eg, upper respiratory infections), it may not be necessary to have disease-specific measurement sets since such an approach might be too burdensome. For chronic patients, severity can indicate the progression of a chronic condition. In this case, the severity of a disease can also be used as an outcome measure of how well the disease is managed. It is possible, however, that a chronic condition is severe from the outset, which must be considered when defining the outcome goals.

The health statuses can further be categorised as single versus multimorbid conditions. For multimorbid patients, it may be impossible to discern the effects of different diseases vis-à-vis functionality and self-reported health status. Thus, general quality-of-life measurements may be more relevant than disease-specific measurement frameworks. Even though multiple chronic conditions are common in the population, especially in older people,[29] outcome measurement studies focusing on multimorbid conditions remain limited.[30]

A similar problem also exists if a patient simultaneously has two or more curable conditions. For example, a person can have severe osteoarthritis while simultaneously suffering from a cataract. When following the disease-specific measurement logic of VBHC, the other condition affects the measurement of the individual's health status and functionality and should somehow be taken into consideration.

The last relevant segmentation dimension is health behaviour, which refers to the risk faced by a healthy person of developing a chronic condition or by a chronically ill person of getting another chronic condition. Preventing diseases is an important objective for an HA. In order to achieve this, it is important to follow the development of health risks in a population, many of which relate to the behaviour of individuals. Thus, classifying all groups (excluding terminal) with respect to health risk is relevant for segmentation.

The relevant variables are arranged as a flowchart algorithm consisting of consecutive questions that produce mutually exclusive segments, as illustrated in figure 2. The flowchart starts with the most severe condition and moves towards mild conditions and healthy individuals. Patients with severe conditions may also experience mild conditions, such as a multimorbid patient with a curable condition and health risks, although the goals for an HA are determined by the most severe condition. Assessments of health status are limited by what data can be collected from the population based on service use, screening and surveys. This inevitable uncertainty is expressed with the phrase 'not that I know of'. Thus, the result of segmentation is never 100% accurate—there are always individuals with diseases that are undiagnosed, as well as individuals with elevated risks of which they themselves or their healthcare providers remain unaware.

The first question in the algorithm is: Does the person have a terminal condition? If so, palliative care is in order. Patient-relevant goals are associated with the quality of death, such as its timeliness and peacefulness.[31] If the answer to the first question is 'not that I know of', the algorithm advances to the next question.

If there is no indication of multiple chronic conditions defined as multiple long-term conditions,[32] the algorithm moves to examine the existence of a single chronic condition. If no chronic condition has been identified for the

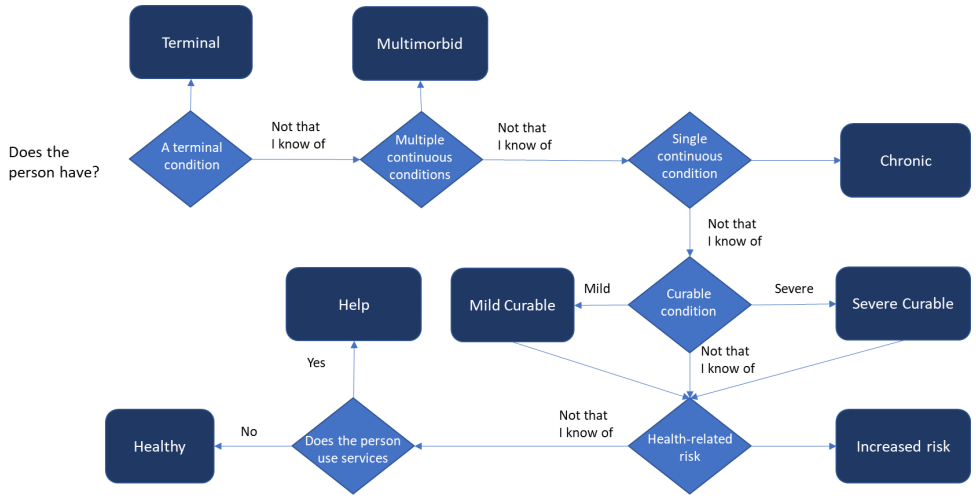

Figure 2 Outcome-based segmentation flowchart based on health status and risk.

individual, the remaining options consist of a curable condition, an elevated risk or being healthy.

If no disease has been identified, the individual can have an elevated health risk or be healthy. The question 'Does the patient have a health-related risk?' can be asked at any point, since an elevated risk can coexist with any medical condition (excluding a terminal condition). Therefore, the 'increased risk' segment can be divided further: (1) people who have no diagnosis, whereby risk is their only known medical issue and (2) people who have a curable or chronic medical condition but are also at an increased risk (see the definition earlier) for some other chronic condition.

The last question is: 'Does the person use services without falling into any of the previous segments?' People using services without a discernible reason are assumed to be seeking help for a perceived problem that has no externally observable manifestation or the need is such that it cannot be fulfilled through the means available within the healthcare system.

The exact outcome goals need to be defined in each organisation in order to align with the organisation's strategy. We have defined examples of outcome goals to illustrate the differences between segments (see table 2). Either the outcome goals or the outcome measurement logic for separate segments differ from each other, indicating that they are meaningful segments for an HA and fulfil the criteria for segmentation. For instance, the measurement logic for severe and mild curable conditions diverges: for severe curable conditions, specific

Table 2 Goals and outcome measurement logic for each segment

Segment	Outcome goal	Outcome measurement logic
Healthy	Keep healthy	Routine surveys concerning health behaviour and health status
Help	Help to find valuable services	Routine surveys considering health behaviour and health status
Increased risk	Mitigate the risk	Risk-specific measures
Mild curable without risk	Solve the health problem	Light generic assessment if problem is solved (PROM)
Mild curable with risk	Solve the health problem Mitigate the risk	Light generic assessment if problem is solved (PROM) Risk-specific measures
Severe curable without risk	Recover from episodes of illness or injury	Health condition-specific measurement sets
Severe curable with risk	Recover from episodes of illness or injury Mitigate the risk	Health condition-specific measurement sets Risk-specific measures
Single chronic	Maintain (or improve) health status and functioning	Health condition-specific measurement sets
Multimorbid	Maintain (or improve) health status and functioning	Assessment of health status and functioning and possibly health condition-specific sets
Terminal	Quality of death	Further research is required

PROM, Patient Reported Outcome Measure.

measurement sets can be employed, but for mild conditions, a simpler approach is justified. The goals for chronic conditions are the same regardless of the number of chronic conditions (single chronic vs multimorbid). However, the measurement logic is different for these groups.

First, an HA needs to determine the size of the population for each segment described in table 2. The size of the segments represents the first means of analysing the health of the population. At a system level, the objective is to prevent people from having multimorbid or chronic conditions and to keep people in the healthy segment as long as possible. Thus, changes in the proportions of segments can be used to assess the performance of the healthcare system and to manage the system.

First, the volume of terminal conditions was estimated through cause-of-death statistics from Statistics Finland. We excluded acute and trauma-based causes of death as they often do not imply a terminal condition as defined in this model and considered only classes of malignant tumours, neurological causes other than strokes and cardiac conditions other than ischaemic heart disease.

Second, the number of chronic patients was defined as the number of patients with an ICD-10 code or ICPC-2 code in primary care, implying a chronic condition as defined in Calderón-Larrañaga *et al*.[33] Multimorbid conditions were defined as patients having two or more of these chronic conditions and single chronic conditions as having only one.

The number of severe cure conditions was defined as patients without chronic conditions who had an inpatient episode in specialist care during 1 year. Mild cure and prevention were defined as the patients who had contact with healthcare services during 2018 but did not belong to the above-mentioned segments. Prevention could not be distinguished from a mild cure based on the information available in our database.

The group of people with an increased risk was difficult to estimate based on register data since it did not include data on health behaviour or laboratory test results. Thus, the increased risk group was estimated based on studies by the Finnish Institute for Health and Welfare.[34]

The results of the analysis of segment volumes based on national register data are described in figure 3. The largest segments were multimorbid, with 1.19 million patients (27% of the population) and single chronics, with 1.59 million patients (36% of the population). Based on studies by the Finnish Institute for Health and Welfare,[34] the prevalence of risk factors in the Finnish population ranges from 10% (regular smoking) to 40% (an elevated total cholesterol exceeding 6.5 mmol/L). Such studies do not consider whether individuals with an elevated risk for a specific disease already have another chronic condition or have sought health services for curable conditions. Therefore, it is impossible to say how individuals with an elevated risk are divided among the 'healthy', 'curable' and 'chronic' categories.

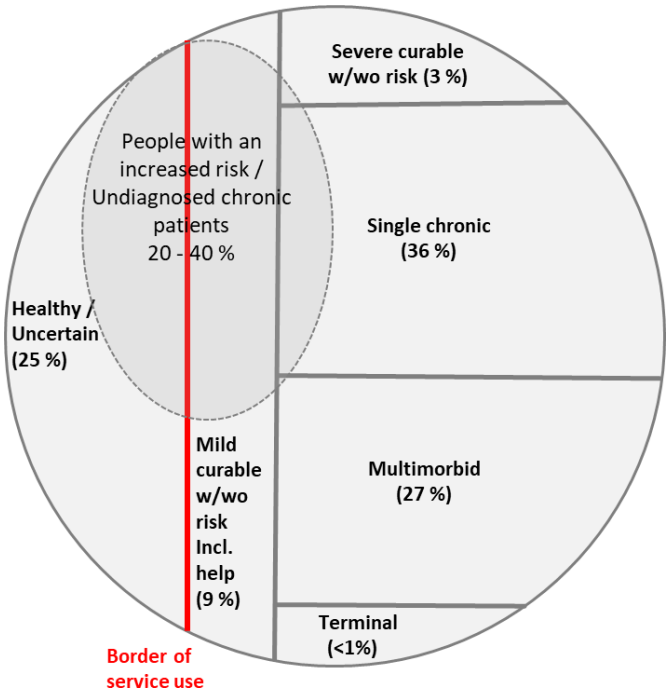

Figure 3 Estimated proportions of different segments based on Finnish data 2018. *People with increased risk may be 20%–40% of the population, depending on the definition and estimates. People with increased risk may belong to 'healthy', 'curable' and 'continuous' categories. The 'help' segment could not be estimated in aggregated data and they are included in mild cure.

DISCUSSION

The concept of VBHC and its application at the healthcare system level have not been widely studied.[4 5] Mjåset *et al*[3] found government involvement to be a key factor for VBHC implementation. The HA needs a systematic segmentation and measurement framework to assess the value of the healthcare system. Many countries have been building outcomes measurement-based disease-specific quality registers, but the problem is that there may be hundreds or thousands of different patient groups, which makes it impossible for HA to get a comprehensive picture of outcomes in the whole population.

The VBHC approach best suits single-disease health problems and treatment episodes. Yet, at the system level, the unit of analysis is the individual rather than an episode. Managing a healthcare system requires a top-down approach to segmentation to include everyone; every person at every point in their life should fit into one segment. The VBHC approach has its purpose: measuring outcomes for individual diagnoses or treatments enables comparisons across providers and treatments to support meaningful and actionable choices for patients. Building the measurement logic bottom-up, disease-by-disease helps service providers improve care outcomes for specific patients, but it may not be the best solution for the system-level measurement of outcomes: either you end up with thousands of segments or you run the risk of omitting some individuals. Furthermore, all multimorbid

cases fall into several segments. How outcome measurements should be organised in such cases has not been captured in disease-specific measurement systems.

The commonly used population-level segmentation model by Lynn *et al*[16] focuses on the descriptive health service needs of a population and is not directly suitable for outcome measurement. The segmentation model of Vuik *et al*[12] divides the population based on observed service use. This offers insights into the different needs of segments (eg, emergency care, home care and specialised care vs primary care), but as such, it is not applicable to defining relevant outcomes for each segment. For example, patients with chronic conditions fall into several segments, and within all segments, there are individuals with no chronic conditions. The other earlier segmentation models[14 15 17] are somewhat similar to ours, but they are either data-driven classifications or they don't divide the population into mutually exclusive groups. Also, neither of their segmentation logic follows VBL and therefore may not support HA in setting goals at the population level.

More detailed grouping or segmentation models (senior segmentation algorithm, clinical research groups (CRG), adjusted clinical groups (ACG), etc.) can be used at the service provider level. Based on the validation of our model in the expert groups consisting of regional management, they have too many groups or do not cover the whole population and therefore cannot be used for population-level analysis or management. Also, since they are based on homogenous resource use patterns, they do not follow the logic of homogenous outcome goals. CRGs or ACGs, as well as ICHOM standard sets, can be used for subgroups within the main segments of the model for a more in-depth understanding of patient groups at the service provider level.

The challenge for the HA is that it wants to improve the health and well-being of the population, but it has to operate through service providers. Pitkänen *et al*[35] demonstrate how the HA can use the population-level outcome-based segmentation model in building governance mechanisms (norms, resource allocations and information sharing) for service providers.

Additional studies are required to deliver more accurate estimations of the size of the different segments, particularly the 'increased risk' segment. In this study, only retrospective register data could be used for the rough estimation of segment sizes. As Finland has quite well-developed national registries, the availability of data may limit the benefits of the segmentation model in practice in other environments. In the future, the segment of each person should be recorded in the electronic medical record systems, which would enable the indication of 'increased risk' as well. In addition, the detailed patient-relevant goals and outcomes can be selected and fined down for each segment having patient representatives in the discussions. Also, in the future, it would be important to calculate cost information for each segment and follow changes in the total cost of each segment and cost per patient in the segments over time. Dividing the segments into smaller groups based on their relative cost levels may also help focus the HA's attention on the most critical areas for improvement. Taking costs as a segmenting variable into account may be most relevant for the single chronic and multimorbid segments and partially for the severe curable segment, as the other segments are naturally low-cost treatments.

The decision-makers of HAs as well as representatives of ministries participating in the expert workshops found the model useful for steering regional health services.[35] They found both segments and outcome goals valuable for steering service provision. The next steps involve measuring the outcomes for each segment based on the goals and logic summarised in table 2 and using the information in decision-making. Although the ultimate goal for the HA is to reach the health goals for the population segments, it can only try to obtain them through the actions of healthcare service providers, who have direct access to the population. What an HA can do is use the health status and outcome information by integrating it into the governance mechanisms for each provider. This includes normative guidance, information sharing and resource allocation principles, as well as reimbursement schemes for providers. Our study is limited to conceptual development and internal feasibility tests and the model requires external validation: how to incorporate outcome-based segmentation into governance mechanisms.

CONCLUSIONS

An outcome-based segmentation model for the entire population is needed if an HA wants to steer the healthcare system, employing the principles of VBHC. Segmentation should be based on the outcome measurement logic and outcome measurements relevant to each segment, and the number of segments has to be limited to get a comprehensive understanding of the whole population. We proposed a segmentation model that divides the entire population into mutually exclusive segments that differ from each other in terms of outcome measurements and outcome goals. We concretise the model by quantifying the segments. This extension of the VBHC theory supports the implementation of VBHC principles at the healthcare system level, giving knowledge management tools for observing and developing outcomes.

Author affiliations
[1]Department of Public Health, University of Helsinki, Helsinki, Finland
[2]Nordic Healthcare Group Ltd, Helsinki, Finland
[3]Turku University Hospital, Turku, Finland
[4]Department of Industrial Engineering and Management, Aalto University, Aalto, Finland
[5]Department of Health and Social Management, University of Eastern Finland, Kuopio, Finland

Acknowledgements We would like to express our gratitude towards the project team, especially Laura Pitkänen, Helena Tolkki and Mikko Valtakari.

Contributors PT: guarantor, conceptualisation, methodology, analysis and writing the original draft; R-LL: guarantor, conceptualisation, methodology, analysis and

writing the original draft; PM: conceptualisation, writing, reviewing and editing; ML: data curation and analysis; PL: conceptualisation, writing, reviewing, editing and supervision. All authors read and approved the final manuscript.

Funding The study was partly funded by Prime Minister's Office of Finland. The funder had no role in study design, data collection and analysis, decision to publish or preparation of the manuscript. Grant number: VNK/79/48/2019.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. Data can be obtained from the national registries of Finland by applying research permits.

ORCID iD

Paulus Torkki http://orcid.org/0000-0002-1127-4205

REFERENCES

1 Porter ME. What is value in health care *N Engl J Med* 2010;363:2477–81.
2 Porter ME, Larsson S, Lee TH. Standardizing patient outcomes measurement. *N Engl J Med* 2016;374:504–6.
3 Mjåset C, Ikram U, Nagra NS, *et al*. Value-based health care in four different health care systems. *NEJM Catal* 2020.
4 Kokko P, Kork A-A. Value-based healthcare logics and their implications for Nordic health policies. *Health Serv Manage Res* 2021;34:3–12.
5 Smith PC, Sagan A, Siciliani L, *et al*. *Building on value-based health care: towards a health system perspective (Internet*). Copenhagen (Denmark): European Observatory on Health Systems and Policies, 2020.
6 Steinmann G, van de Bovenkamp H, de Bont A, *et al*. Redefining value: a discourse analysis on value-based health care. *BMC Health Serv Res* 2020;20:862.
7 Nguyen H, Manolova G, Daskalopoulou C, *et al*. Prevalence of multimorbidity in community settings: a systematic review and meta-analysis of observational studies. *J Comorb* 2019;9:2235042X19870934.
8 Vuik SI, Mayer EK, Darzi A. Patient segmentation analysis offers significant benefits for integrated care and support. *Health Affairs* 2016;35:769–75.
9 Lillrank P. *The logics of healthcare*. Boca Raton, Fl: CRC Press/Taylor and Francis, 2018.
10 Peltokorpi A, Linna M, Malmström T, *et al*. Five focus strategies to organize health care delivery. *Int J Health Care Qual Assur* 2016;29:177–91.
11 Chong JL, Lim KK, Matchar DB. Population segmentation based on healthcare needs: a systematic review. *Syst Rev* 2019;8:202.
12 Vuik SI, Mayer E, Darzi A. A quantitative evidence base for population health: applying utilization based cluster analysis to segment a patient population. *Popul Health Metr* 2016;14:44.
13 Yan S, Kwan YH, Tan CS, *et al*. A systematic review of the clinical application of data-driven population segmentation analysis. *BMC Med Res Methodol* 2018;18:121.
14 Lillrank P, Groop PJ, Malmström TJ. Demand and supply–based operating modes—a framework for analyzing health care service production. *Milbank Q* 2010;88:595–615.
15 Brommels M. Patient segmentation: adjust the production logic to the medical knowledge applied and the patient's ability to self-manage—a discussion paper. *Front Public Health* 2020;8:195.
16 Lynn J, Straube BM, Bell KM, *et al*. "Using population segmentation to provide better health care for all: the "bridges to health" model". *Milbank Q* 2007;85:185–208;
17 Madotto F, Riva MA, Fornari C, *et al*. Administrative databases as a tool for identifying healthcare demand and costs in an over-one million population. *Ebph* 2013;10:1–11.
18 Dresch A, Lacerda DP, Antunes Jr JAV. *Design science research*. Cham: Design Science Research. Springer, 2015.
19 Wedel M, Kamakura WA. *Market segmentation: conceptual and methodological foundations*. Boston, MA: Springer Science+Business Media LLC, 2000.
20 Huber M, Knottnerus JA, Green L, *et al*. How should we define health? *BMJ* 2011;343:d4163.
21 Johnston MC, Crilly M, Black C, *et al*. Defining and measuring multimorbidity: a systematic review of systematic reviews. *Eur J Public Health* 2019;29:182–9.
22 Keeler EB, Manning WG, Newhouse JP, *et al*. The external costs of a sedentary life-style. *Am J Public Health* 1989;79:975–81.
23 Manning WG, Keeler EB, Newhouse JP, *et al*. *The costs of poor health habits*. Cambridge, Mass: Harvard University Press, 1991.
24 Pronk NP, Goodman MJ, O'Connor PJ, *et al*. Relationship between modifiable health risks and short-term health care charges. *JAMA* 1999;282:2235–9.
25 Prah Ruger J. Health capability: conceptualization and operationalization. *Am J Public Health* 2010;100:41–9.
26 Verweij M, Dawson A. The meaning of 'public' in public health. In: Dawson A, Verweij M, eds. *Ethics, prevention, and public health*. Oxford: Oxford University Press, 2007.
27 Brülde B, Dawson A. *Health, disease and the goal of public health, public health ethics*. Cambridge University Press, 2008.
28 Munthe C. The goals of public health: an integrated, multidimensional model. *Public Health Ethics* 2008;1:39–52.
29 Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition—multimorbidity. *JAMA* 2012;307:2493–4.
30 Smith SM, Wallace E, O'Dowd T, *et al*. Interventions for improving outcomes in patients with multimorbidity in primary care and community settings. *Cochrane Database Syst Rev* 2021;1:CD006560.
31 Olthuis G, Dekkers W. Medical education, palliative care and moral attitude: some objectives and future perspectives. *Med Educ* 2003;37:928–33.
32 NICE. Multimorbidity: clinical assessment and management NICE guideline published. 2016. Available: www.nice.org.uk/guidance/ng56
33 Calderón-Larrañaga A, Vetrano DL, Onder G, *et al*. Assessing and measuring chronic multimorbidity in the older population: a proposal for its operationalization. *J Gerontol A Biol Sci Med Sci* 2017;72:1417–23.
34 Koponen P, Borodulin K, Lundqvist A, et al., eds. *Terveys, toimintakyky ja hyvinvointi Suomessa. Finterveys 2017 -tutkimus. Raportti 4/2018*. Helsinki: Finnish Institute for Health and Welfare, 2017. Available: https://www.julkari.fi/handle/10024/136223
35 Pitkänen LJ, Leskelä R-L, Tolkki H, *et al*. A value-based steering model for healthcare. *Front Health Serv* 2021;1:709271.