

# Improving the quality of patient care

Charlotta Lindvall MD PhD, a physician scientist at the Dana-Farber Cancer Institute, is focused on implementing quality measures to improve patient care, especially among frail and seriously ill patients. Using artificial intelligence and machine learning techniques, in the form of natural language processing (NLP), her lab can extract patient-centred information from millions of electronic medical records. They then apply these algorithms to measure the quality of care provided. This enables benchmarking and continuous improvement to the quality of patient care.

A vast amount of information is exchanged between patients and clinicians within the confines of a medical examination room. The patients describe their ailments, express their concerns, state their symptoms and provide overall narratives depicting how they are feeling. The doctors deduce the causes of the ailments, discuss possible treatments, assess potential side effects and document essential physical information.

Quantitative data, for example body temperature and blood work, can be logged and tracked. Much of the qualitative data, such as patients' descriptions of their frequent nausea or how they are feeling in general, however, is manually typed by doctors in a free text format in the clinical visit notes. In order to measure the quality of care provided for patients and recommend improvements, analysis of both quantitative and qualitative data is required. However, this analysis is impossible unless all data has been successfully captured.

## MEASURING THE QUALITY OF HEALTHCARE

Dr Charlotta Lindvall's research at the Dana-Farber Cancer Institute is focused on improving patient care. It involves the use of artificial intelligence (AI) and machine learning to extract patient centred information from electronic health records (EHRs). While we come across this technology every day, for example with shopping or banking, Dr Lindvall points out that it is underutilised in clinical medicine, particularly as it offers such potential for the improvement of patient care.

Together with researchers at Massachusetts Institute of Technology and palliative care doctors at Dana-Farber Cancer Institute, Dr Lindvall is introducing innovative techniques to improve the measurement of quality in healthcare, with particular emphasis on palliative care. Palliative care is the specialised medical care focusing on providing relief from the pain, symptoms and stress of advanced progressive illness; where the aim is to improve the quality of life of the patient and their family.

## MEASURING PROCESS OF CARE

Measurements of care quality are used to gauge how well a health provider is delivering care to its patients. These measurements reflect various parameters such as standards of care and practice guidelines. Medical information from patient records is converted into a numerical quality measurement, a rate or a percentage, which enables providers to assess and effectively measure their performance. Converting qualitative patient information embedded in the clinical visit notes into quantifiable numeric values, however, is not straightforward.

Numerous barriers obstruct the use of current data records to measure processes of care. Administrative claims data, generated for the administration of payment to healthcare providers and facilities for health services, do not contain information on essential serious illness care processes. While clinical notes contain a great deal of these data, extracting it manually is time-consuming and costly. Dr Lindvall is overcoming these barriers by employing natural language processing to extract information from electronic medical records.

## NATURAL LANGUAGE PROCESSING

Natural language processing (NLP) is an area of artificial intelligence, which facilitates the understanding, interpretation and manipulation of human language with computers. NLP draws from various disciplines, including computer science and computational linguistics, in the quest to bridge the gap between human communication and computer understanding. Using NLP, computers can read text, listen to speech and interpret it, measure sentiment and determine which parts are important. This makes it possible to analyse massive amounts of language-based data in a consistent, efficient and unbiased manner.

## STRUCTURING AN UNSTRUCTURED DATA SOURCE

NLP helps resolve ambiguity in speech and provides a valuable numeric structure to the data, enabling applications such as speech recognition and text analytics (i.e. drawing meaning out of written communication). Dr Lindvall and her colleagues are using this technology "to create pathways that will make qualitative data much more quantitative than it ever has been in the past". Advances in NLP together with EHRs provide the potential to overcome the barriers by using computers to analyse unstructured text from clinician notes. Lindvall remarks, "If my 14-year-old can check her math homework via natural language processing, we ought to use that information technology to improve patient care."

Dr Lindvall describes how this novel NLP methodology, "can access rich information in the patients' charts that reflect what matters to them and their families". She continues that, "this

The inset text contains an example of the type of patient-centred information Dr Lindvall's work highlights.



## Dr Lindvall employs natural language processing to extract information from electronic medical records.

is documented in the medical record, but patients with a serious illness like cancer have so many notes that the patient experience often gets lost in manual chart review. Even the most well-intentioned clinicians, who wish to meet each goal of patients, cannot be expected to review 300 chart notes for each patient. So, we have to find a way to extrapolate the most critical information for them about goals, symptoms, and objectives."

## RESEARCH GOALS

Currently, numerous hours are spent searching through a myriad of paper and electronic notes to find information on patients' symptoms, health care proxies, end-of-life conversations and preferences. The more critical and complex a patient's illness is, the longer it takes to establish an understanding of their condition.

Dr Lindvall's work includes the bringing together of significant information from different sources into a single resource. Then various health providers will be given easy access to it so that they can find specific patient information,

without the need to dig through piles of paperwork. This information resource includes symptom documentation that can be analysed to reveal hidden trends based on things that patients mention to their doctor in passing, which currently are not noted as they do not fall into the check-boxes listed on a chart.

The researchers intend to create partnerships with palliative care teams in order to improve the communication between providers and patients. This tool can help educate providers with respect to suitable end-of-life conversations with patients. It can also provide advice regarding the most effective ways to establish goals and priorities, with both patients and their families, while they are in appropriate mindsets.

This work will enable the analysis of documentation (or indicate the lack of documentation) of patient goals before surgery or other invasive treatment is carried out. The aim of palliative surgery is to alleviate pain and improve symptoms, providing relief but not a cure, so the conventional 30-day survival



Qualitative data, for example a patient's description of how they feel, is recorded differently to quantitative data, making it more difficult to capture and analyse.



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measure for surgery success does not apply. Instead, providers will be able to identify whether surgeries are successful by assessing the patients' symptoms and goals of care, rather than their survival.

The research also aims to improve patient outcomes by increasing the amount of information available to physicians. Conventional data mining is an arduous task that can only cope with relatively small data sets, therefore limiting the number of patients that can be included in a study. Computer assisted language processing, however, utilises modern computer technology to process much larger data sets. For example,

there may be only one person who matches a particular set of demographic characteristics in a sample of 1,000 people. If the sample size can be increased to 100,000, then approximately 100 people will match the particular set of characteristics, therefore increasing the accuracy and precision of predictions such as the likely impact of a procedure or treatment. This will enable patients, and their families, to make more informed decisions about their care.

**THE APPLICATION OF NLP TO PALLIATIVE CARE**

The researchers have developed an NLP software package that can extract



Natural language processing can be applied to existing electronic health records – doctors do not need to record information in a different way in order for it to be effective.

information from clinical notes. NLP can harvest predefined elements from unstructured data, such as operative reports, which are then encoded into a structured dataset that can be analysed relatively easily.

NLP can be applied to existing EHR data and it has the ability to process very large datasets. This enables widespread implementation of the methodology as well as facilitating low cost analysis of population-based studies. These assets have already underpinned the use of NLP to solve issues in the fields of oncology and palliative care.

Dr Lindvall draws attention to the fact that there are currently no quality measures in place for palliative surgery. With the need to improve both the quality and the value of end-of-life care, palliative surgery is attracting attention as an area that currently lacks a robust quality metric. This measurement is necessary for the benchmarking and continuous improvement of the quality of patient care. Measures for processes of care, exemplifying the highest standards for the management of patients nearing the end of their lives already exist, but these have not been applied to palliative surgery.

**MEASURING QUALITY IN PALLIATIVE SURGERY**

The research team have used NLP technology to analyse the documents contained in EHRs and propose that four processes of care are applied to the field of palliative surgery: goals-of-care conversations, clarifying code status, assessment for hospice and palliative care consultation. These processes have already been accepted to be quality

metrics when managing the care of seriously ill patients. Essentially, if these four processes are performed effectively, care is considered to be of high quality.

**GOALS-OF-CARE CONVERSATIONS**

A goals-of-care conversation helps the clinician identify a patient's wishes and treatment choices. Decisions that are made in the context of a life-threatening illness are influenced by the individual's values and preferences. Understanding a patient's goals of care enables the clinician to align the care and treatment provided for the patient with what is important to them and their family. Irrespective of the treatment outcomes, palliative surgery that is not in agreement with the patient's values depicts poor quality care. Discussing and documenting the patient's goals of care prior to palliative surgery ought to be standard practice. It is not known, however, to what extent these discussions currently take place and are recorded in clinical practice.

**CLARIFYING CODE STATUS**

Patients must select a code status so that their caregivers and loved ones can follow their wishes. Full code means that if a patient's heart stops and/or they stop breathing, all resuscitation procedures will be provided to try to keep them alive. Limited code means that only specific resuscitation procedures will be employed. DNR stands for 'do not resuscitate' and indicates that if a patient's heart stops and/or they stop breathing, the patient will be allowed to die naturally. Comfort care means that the patient will not be resuscitated, but medical treatments promoting comfort will be provided.

Many patients with terminal cancer prefer to forego interventions and do not choose full-code status. Due to the risks involved in surgery, it is essential to clarify a patient's preference prior to a surgical operation. For patients who have chosen limited codes, DNRs and comfort care, the American College of Surgeons states that surgeons are responsible for instigating a conversation regarding the reconsideration of code



A goal-of-care conversation helps the clinician identify a patient's wishes and treatment choices.

status and documenting plans to include any changes. Unfortunately, the data on compliance with these guidelines is limited.

**ASSESSMENT FOR HOSPICE**

More end-of-life patients are choosing hospice care and it is perceived as offering better quality care. Enrolment in hospice before death is a quality measure

choose to use it, could account for the disparity in patients' preferences and offer a more accurate tool for measuring hospice utilisation.

**PALLIATIVE CARE CONSULTATION**

Increased access to palliative care is required to deal with the needs of seriously ill patients. The American College of Surgeons recognises the valuable role played by palliative care for seriously ill patients undergoing surgical treatment. Some surgeons, however, are reluctant to use palliative care and restrict it to the elderly and critically ill patients, or those for whom death seems imminent. Patients undergoing palliative surgery already meet established criteria for the assessment of palliative care. The use of a palliative care consultation, to discuss its suitability with patients, is therefore an important process of care.

**DEVELOPING THE NLP MODEL**

The biggest challenge with NLP is building a key library of terms for each concept. Dr Lindvall and her team conducted a detailed literature review to identify conceptual domains. This was followed by qualitative discourse analysis of EHR notes. Two of the physician researchers read medical records and identified documentation pertaining to the four processes of care. The words

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for patients with cancer. Many patients undergoing palliative surgery have life expectancies of less than six months, yet studies show that surgical patients are less likely to receive hospice care. If they do receive hospice care, it is more likely to commence within days of death.

Patients choosing palliative surgery are opting for more aggressive treatments near end-of-life and may be less inclined to enrol in hospice. If their physician discussed their prognosis and hospice care with them, it could mean an increase in hospice utilisation and encourage earlier enrolment. Currently, administrative claims data only identifies patients that have selected hospice care. Recording when patients are offered hospice, regardless of whether they

In palliative surgery, the outcome of quality of life is used to assess success rather than the 30-day survival outcome used in other areas.



and phrases that they found to be connected to a particular process of care were then added to a key term library. A manual review of the EHR notes identified by NLP was completed to validate the key term libraries. The notes that were not identified by NLP were also reviewed. Over time, the repetition of this process honed the NLP performance, producing the 'gold standard' chart review.

The performance of the NLP libraries was then compared with the findings of a manual chart review of the clinician notes, procedure reports, and radiology reports of a random sample of 20 pancreatic cancer patients who underwent palliative procedures between 2011 and 2016. The researchers captured information relating to the four processes of care from the 241 notes accumulated by the 20 patients during their hospitalisation. NLP was carried out and the results were compared with findings from the gold standard chart review. The NLP libraries' sensitivities (the proportion of actual positives that were correctly identified) and specificities

(the proportion of actual negatives that were correctly identified) ranged from 93.8% to 100%. The manual review and data entry took over 20 hours to complete, whereas the NLP search extracted the information and generated a structured dataset in just 26 seconds. Using NLP to apply these quality measures is, therefore, both practical and achievable.

#### WIDER IMPLICATIONS

The National Academy of Medicine highlights the need for increased access to palliative care and states that empowering patients by aligning care decisions with their personal goals is a vital health care priority. They also note that it is imperative that processes and outcomes can be measured in a meaningful way.

While some process measures for palliative medicine already exist, and may be suited to palliative surgery, their large-scale implementation has been slow. This is partly due to issues with the existing data collection methods.

NLP is limited in that it can only detect whether processes are or are not documented. The documentation of these processes, however, is intrinsic to improving quality of care. It also offers context for future conversations, so documentation must be considered a quality measure in itself.

Dr Lindvall says, "we are ensuring that patients' voices have been heard and documented, and that conversations about their goals take place." She continues to highlight that, "there is real data in the conversations providers have with patients; we want to make this data easily available to researchers so we can better understand patients' experiences, see what commonalities exist among us, and work to make the most educated decisions possible."

The research team aims to develop and validate standardised libraries of terms that will facilitate the measurement of these processes of care across medical facilities. This will enable benchmarking and continuous quality improvement. They also intend to examine the relationship between the four processes of care and subsequent treatment decisions.

Although this project focuses on palliative care and cancer treatments, Dr Lindvall believes that the NLP model is relevant to all areas of healthcare.

**Results from preliminary work suggest that Dr Lindvall's NLP approach ... is more than 2700 times faster than reviewing charts manually.**



# Behind the Research

## Dr Charlotta Lindvall

E: [clindvall@mail.harvard.edu](mailto:clindvall@mail.harvard.edu) T: +1 617 632 6464 W: <https://lindvalllab.com/>

### Research Objectives

Dr Lindvall is a palliative care clinician investigator focused on improving the quality of care for patients with serious illness and their families. Her current program of research focuses on 1) understanding national trends in the use of invasive procedures in patients with serious illness and 2) developing computational methods to identify patient-centred outcomes documented in the electronic health records. Her lab, [www.lindvalllab.com](http://www.lindvalllab.com), is developing computational methods to capture patient-centred clinical data in the electronic health records, with the goal of improving healthcare value and quality. Dr Lindvall's ultimate goal is to develop and implement scalable quality improvement programs that utilise AI methods such as natural language processing (NLP) and machine learning.

### Detail

Charlotta Lindvall, MD PhD  
Dana-Farber Cancer Institute  
450 Brookline Ave, LW670  
Boston, MA 02115, USA

Department of Psychosocial Oncology and Palliative Care at the Dana-Farber Cancer Institute, Boston.

- James Tulsky, MD  
Dana-Farber Cancer Institute
- Zara Cooper, MD  
Brigham and Women's Hospital

#### Bio

Dr Lindvall earned her MD and PhD (medical genetics) at the Karolinska Institute in Stockholm, Sweden. Following residency in Internal Medicine, she completed fellowships in Palliative Medicine and General Medicine at Harvard Medical School, Boston. She is currently a physician scientist in the

#### Funding

- Gloria Spivak Fund
- National Palliative Care Research Center
- Palliative Care Research Cooperative Group

#### Collaborators

- Regina Barzilay, PhD  
Massachusetts Institute of Technology (MIT)

The technology is being tested in research projects at:

- Partners HealthCare
- Stanford University
- Mayo Clinic
- Duke University Medical Center
- Northwell Health
- Beth Israel Deaconess Medical Center
- Veterans Affairs

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### Personal Response

#### What inspired you to apply computer technology to the medical field of palliative care?

// I have always been interested in math, and that led me to pursue a PhD in medical genetics. When I began residency, I was surprised by the underutilisation of data in clinical medicine and I worried about its potential adverse impact on patient care, especially for patients with life-limiting illness. Repeatedly I noticed that, compared to the research lab, only a select number of data sources were used to guide clinical decision-making. I strongly felt that my research skills from genetics could have more direct impact on patient care if I applied them to clinical data. //