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Lay Summary

The valuation of medical interventions at the end of life

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1. Background

The backdrop to our research project are claims, made in the media and by professional economists, that the health expenditure at the end of patients' lives greatly exceeds the benefits. One frequently repeated finding is that 25% of a person's total health spending takes place during his or her last year of life.[1] One reason for this is certainly that older people have more health problems and therefore higher costs, but another driver for this situation are treatments of terminally ill patients that are very costly, but which increase life expectancy by very little. Salient examples are cancer treatments that cost tens of thousands of Swiss francs, but which extend life only by 1-2 months, if at all. Although life per se is priceless, it is nevertheless true that resources spent on marginally increasing life expectancy could be used for other purposes, and which may be socially preferable. To provide an example, rather than spending another 500 million francs to extend the lives of terminally ill patients by a few weeks, one could invest this money in preventative health programs or education. In general, every franc spent for one purpose cannot be spent for another. It is therefore necessary to compute the full costs and benefits associated with public programs in order to know whether we should increase or decrease spending, or keep it roughly constant. This is particularly important in the health context, as health expenditures as a share of GDP have increased steadily over the last decades and continue to do so. Limiting the growth of health expenditure at the end of life could help curbing the growth in total health expenditure. This sets the stage for our first part of our project.

In the hopes of limiting the growth in health costs, Switzerland has instituted a national reform of how hospitals are paid for the treatment of patients. In the past, cantons were free to the payment system of their choice. However, economic theory and (some) empirical evidence suggest that "prospective" payment schemes (where hospitals are paid a fixed amount of money based on the diagnosis of a patient) have important advantages relative to "retrospective" schemes, were hospitals are reimbursed for every additional procedure and for every day that a patient stays in the hospital. Since 2012, all cantons are required to use a prospective scheme based on a patient's main diagnosis. This reform forms the background for the last part of our project.

2. Goals of the project

The overall goal of our project is to understand the mechanisms of the delivery of health care at the end of live. In our project, we approached this goal from three different directions, each of which resulted in an independent article that will be published in a peer-reviewed economics journal. The three articles are the basis for the dissertation of Matthias Minke at the Faculty of Business and Economics of the University of Basel, under the supervision of Prof. Beat Hintermann. Accordingly, all sections of this summary (goals, methods, results) contain three subparts, one for each paper.

In the first paper, we focus on the question of how resources should be allocated across different sectors in the economy, and within the health sector, across "regular" and the "end-of-life" treatments. In a second step, we allow for the presence of learning spillovers: We posit that when applying treatments to terminally ill patients, health professionals gain knowledge that will ultimately lead to an improvement of the treatment. Because this benefit only occurs later, and sometimes even in the context of different

[1] These results are based on people covered by the Medicare system in the USA; no equivalent numbers exist in the Swiss context, but the probability of hospital admissions also increases sharply in people's final months of life.

diseases, using the benefits only for the involved patients provides underestimates the true societal benefits of applyling seemingly futile treatments. For example, the application of cancer treatments that at the time led to only modest increases in life expectancy has allowed for the development of techniques that now can significantly extend the life of cancer patients, and in some case even stop the progress of the disease altogether. Another way of putting this is that progress is due to small and incremental steps, each of which seems insignificant, but in combination they lead to a significant increase in the effectiveness of treatment.

The purpose of the second paper is to fill a gap concerning mortality data, which is published only for a subset of diseases. For this, we propose and estimate a methodology that allows to obtain comprehensive mortality estimates from hospital discharge data. As these are routinely gathered it is a cost-effective way to analyze survival rates after treatment for a broad range of diseases. This is important as mortality rates are a widely used measure for the success of therapies, preventive measures and even health systems as a whole. Information on cause-specific mortality rates often guides policy makers and health practitioners in the decision on how to allocate health budgets. It is therefore important to obtain accurate estimates of mortality and survival rates. In the context of our overall project, we were motivated by the fact that an implementation of the aforementioned theoretical model requires knowledge about treated and untreated mortality rates, which is available only for a limited number of diseases and health conditions.

In the third and last paper of the project, we aim to shed some light on the relationship between payment of hospitals and the pattern of care at the end-of-life. There is a general concern that economic incentives shape the kind of care offered by hospitals in a way that is not necessarily beneficial to patients nor cost-effective. This concern was also one reason to implement a prospective payment scheme called SwissDRG for financing hospitals in Switzerland. Reimbursement schemes can be distinguished into two types. Retrospective schemes are based on the actual incurred costs, and the payment is determined after the treatment is completed. In contrast, prospective payment schemes determine the payment before the treatment, based on average costs and best practices information collected at selected hospitals. Both systems have their advantages and disadvantages. While retrospective schemes bear incentive for overtreatment, prospective schemes come with other problems for example that hospitals try to attract patients with below-average costs. We check the effects of the prospective payment reform on patients at their end-of-life by empirically analyzing level changes of a set of treatment intensity indicators. These indicators consist of: The length of hospital stay, the number of hospital admissions, palliative care, chemo-therapy, use of intensive care, re-animations during a given hospitalization, tracheotomy, and parenteral nutrition.

3. Methods

Given the increase of health care costs towards the end of life, some commentators and researchers suspect a misallocation of resources that would otherwise be available for alternative uses within, or outside, the health care sector. This claim is based on a comparison of the costs of terminal care and the monetized benefits of a life extension implied by the value of a statistical life year (VSLY). The empirical literature defines end-of-life costs as those that take place during a given time range, usually a year, before a patient's death. However, one should be cautious about judging the usefulness of health interventions at the end of life computed from this ex-post point of view, because a significant share of "end-of-life"

expenditures may be associated with treatments that, on average, are quite effective.[2] In contrast, if we think about end-of-life costs from an ex-ante perspective, which is more appropriate in the context of a cost-benefit analysis, we should define those expenditures as "end-of-life" that are associated with treatments that do not significantly alter survival prospects. In the first paper, we use this ex-ante concept of end-of-life health costs and develop a theoretical model in which a social planner allocates resources across consumption and health. Our model allows for treatment options that vary in their effectiveness (i.e., the extent to which they can reduce the mortality rate associated with a disease) and a population that varies in the degree of health. Solving the model yields a condition that states that at the social optimum, the marginal cost of saving a statistical life year (MCSLY) has to be equal to the VSLY for all treatment options.

We propose learning externalities as a rationale for why the benefits from seemingly useless medical treatments may exceed the VSLY associated with the treated patients themselves. We posit that health professionals learn when treating terminally ill patients. Although learning takes place in all health interventions, we argue that the learning effect is larger when treating diseases that are currently not well understood and thus constitute the medical frontier. Learning in the context of one disease may produce knowledge that turns out to be useful in the treatment of other diseases, as suggested e.g. in the case of beta blockers.[3] Our externalities model is motivated by the observation that technological progress has been a major cause underlying the increase in life expectancy. However, because we all die at some point, a decrease in the mortality rate associated with a particular disease leads to a shift in the cause of death to other diseases over time. We capture this dynamic feature in a static framework by assuming that the treatment effectiveness of the end-of-life disease group, the composition of which will generally change over time, remains low regardless of the technical progress in the rest of the health sector.

In our application, we focus on admissions to intensive care units (ICUs) and separate diseases into cancer (which constitutes our "end-of-life" sector) vs. all other diseases. We calibrate the free model parameters using ICU admission rates, survival rates, treatment costs, overall health expenditure, aggregate income and an estimate for the VSLY from the literature. We solve the model for different magnitudes of learning spillovers that arise from the treatment of cancer cases. This allows us to make statements about the optimal divergence between the MCSLY and the VSLY in the presence of different degrees of learning spillovers.

For the second paper, we employ three methodological ingredients. First, we built on an existing econometric framework to estimate unobserved out-of-hospital mortality and extend it for patient histories that consist of multiple hospitalizations (multistate model). This allows us to exploit the fact that the health state of a patient changes throughout his or her history. We estimate the multistate model with a non-linear estimation technique, so-called duration analysis. This technique differs from standard linear

[2] For example, if a treatment has a 80%-chance of averting death, the costs associated with the remaining 20% will be labeled "end-of-life" from an ex-post-view, even though this is clearly not a treatment that would be labeled futile considering the survival rate. As a second example, consider a two-step process that consists of diagnosis followed by treatment. The first step involves acquiring costly information about a patient's survival prospect. Even if hopeless cases are ultimately not treated, the costs of determining that they are hopeless will count towards end-of-life HCE in an ex-post context.

[3] Gelijns and Rosenberg (1994) report an example of positive learning spillovers where the use of beta blockers has spread from two cardiovascular conditions to more than twenty diseases. Romley et al. [2011] study the effect of hospital spending on inpatient mortality in California from 1999 to 2008 and find a significant negative relationship between end-of-life expenditures and overall hospital mortality for six major diagnosis groups, which provides indirect evidence for the existence of learning spillovers.

models insofar as it enables us to estimate the distribution of time, not only a specific moment of the distribution. This comprehensive information is required if one is not only interested on whether an event (e.g. a death, relapse, remission) occurs but also when. Applications of such techniques are therefore not limited to health but also for instance to study labor markets.
Second, we use the raw estimates of the empirical model as an input to simulate the unobserved out-of-hospital events, which are consistent with the estimated mortality, discharge and readmission rates from the hospital data set. This eventually puts us in a position as if patients could be followed up even after the last discharge from hospital. The so created pseudo data does then serve as a basis to estimate disease-specific survival times after initial hospitalization.
Third, we contrast this method with a simpler single-risk model, that does only use the information on the first and last observable hospitalization of a given patient, neglecting intermediate admissions for treatments in a hospital. This estimation yields only estimates of the mortality rates which then serve as input to predict disease-specific survival times.

In our third and final project contribution, we use quasi-experimental design to identify the effect of a policy reform. Quasi-experiments are a popular setting for empirical studies in the applied social sciences and economics. These differ from laboratory experiments known from natural sciences in terms of controlled conditions such as a randomization of subjects into a control and treatment group. Such ideal experimental designs are, however, very rare in the social sciences as they usually involve substantial costs and often pose ethical problems. A way to circumvent this problem is to use real world interventions in which some subjets are affected (or more effected) by an intervention than others and that this asymmetric effect is – potentially after controlling for confounding factors – as good as random.
The nationwide introduction of a DRG system to reimburse hospitals in Switzerland offers such a quasi-experimental setting. The fact that some cantons already had a DRG system allows us to divide cantons in to a treatment group (those that were forced to switch to a prospective system due to the reform) and a control group (cantons that used a prospective system even before the reform). The effect of the switch to the prospective DRG system can then quantified using a so called difference-in-differences estimation. This approach allows to control for any time-constant differences between the treatment and the control group and thus permits to identify the effect of the policy reform from other confounding factors. In practice, however, there are several assumptions to be met and limitations, whose discussion would go beyond the scope of this summary.
We then analyze the effect of the prospective payment reform on the treatment intensity indicators mentioned in the section 2. For an operationalization of the end-of-life treatments we look at patients during their final 12 months of life.

4. Results

The theoretical framework of our first paper gives no evidence that cost and benefits of end-of-life health care should – *in principal* - be evaluated on different grounds than other parts of health care such as for example preventive measures. This conclusion is altered if end-of-life care is associated with learning effects that improve current or future effectiveness of treatments. There is reason to believe that this learning plays indeed a role as end-of-life care is often associated with diseases that currently are not well understood and therefore exhibit a steeper learning curve than other well understood diseases. We find

that even modest learning effects may warrant a substantial increase in the optimal level of care at the end-of-life. For example, if the application of end-of-life treatment is associated with learning effects that ultimately increase the survival rate for „regular“ diseases by one precentage point (which seems at least possible), then this suggests that we should spend up to 78% more on these treatments than if we were to neglect learning effects at all. However, it is important to point out that we do not prove the existence nor measure the strength of actual learning effects. We simply show by how much optimal spending on end-of-life health care should be inceased *conditional* on a given level of learning spillovers. If no such spillovers exist, then the monetized benefits of the involved patients have to be at least as large as the costs.

The application of the methodology in paper 2 yields a detailed time structure of patients' predicted hospital stays and survival times. This can be differentiated for various diseases and separated for geographic regions. We find, however, that the proposed multistate estimation technique does not pay off in terms of an increased accuracy of the prediction. If, however, one is interested in the intermediate transitions and how these are affected differently by the set of covariates or differ across regions, the proposed model might still be the model of choice.
We find that in order for the multistate method to result in consistent estimates, the selected diseases must be associated with (i) a sufficiently high mortality and (ii) a sufficiently high re-hospitalization rate, and (iii) that the rehospitalization occurs within a sufficiently short time frame.
Overall, we find a surprisingly good fit of the single-risk model, which suggests that this approach may therefore serve as a cheap complement in cases where a registry is not established.

In our final paper, we find find mixed effects of the prospective payment reform on the pattern of care as reflected by the selected set of indicators. Our results suggest that a switch to a prospective DRG scheme is associated with a decrease in the average length of hospitalization spells and an increase in the propensity to receive palliative care among deceased hospital patients. These results remain stable for a row of alternative model specifications and different time spans prior to death. For the other examined indicators, such as the frequency of hospitalizations, the propensity to receive chemo-therapy, parenteral nutrition, or the usage of intensive care units, we find no significant effects, neither positive nor negative ones.
According to the WHO, palliative care differs from other care in terms of its ultimate goal. Surgical or medical treatment usually are intended to cure a patient or at least to sustain life. Palliative care's goal is to improve the quality of life rather than extending its length for patients' in their final phase of life. The estimated effect thus suggests that the DRG reform has led to less aggressive care at the end-of-life. However, this interpretation is preliminary without a deeper understanding behind the precise channels and mechanisms underlying these results.

5. Significance of the results for science and practice

The results of our first paper suggest two things. First, there may be a need for rationing in public health insurance to ensure that the benefits of an intervention justify the costs. As a society, we want to use resources where they have the greatest effect. This rule applies to spending on health just as it applies to spending on education or infrastructure, and spending on end-of-life health care should be no exception.
Second, if learning effects are important in the context of applying terminal care, for which there exist economic arguments and also some anecdotal evidence, then we have to consider the total societal benefits of terminal care rather than just the benefits accruing to the patients that are treated. For

example, if the application of a particular treamtment, although currently not very effective, allows for an eventual improvement of the treatment effectiveness, then this has to be considered in a comparison of the societal costs and benefits of terminal health care. This suggests that rules for rationing health care should take learning externalities into account.

The methodology that we develop in our second paper may be helpful for applied researchers or hospital planners to analyze and predict re-admission patterns after initial treatment. This could for example be helpful to determine whether a certain treatment practice would decrease the burden of frequent re-admission to a hospital. Moreover, the estimated disease-specific mortality rates may serve as a complement to existing registry data as for example to the Swiss national cancer registry (NICER).

The results of our third paper are of relevance for health policy as DRG based hospital payment systems are subject to criticism. It is therefore important to learn if the criticism is warranted on empirical grounds. As there is a large number of countries (for example Germany, England, Netherlands, Poland) that have introduced a DRG system in the past and other countries may follow in the future, the policy relevance is not restricted to Switzerland. Our results therefore also inform policy makers in other countries. Overall, the paper adds to the existing literature on payment reforms in the hospital sector and increases our knowledge of treatment patterns at the end-of-life.