Information and Incentives in Medical Decision Making – Five Essays

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Introduction

Introduction

> "But information, in the form of skilled care, is precisely what is being bought from most physicians, and, indeed, from most professionals." (Arrow, 1963, p. 946)

In this quote, Arrow highlights the important role of information in healthcare. Physicians know more about diagnosis and options for medical treatment than patients and thus help patients to make informed decisions. The quote also refers to the fact that physicians are paid to provide the relevant information - often by an employer or a health insurance company. This points towards the (financial) incentives physicians can be exposed to. Incentives may influence how much time physicians spend with patients and what medical treatment they recommend. However, physicians' interests induced by incentives may not always be aligned with patients' interests. Moreover, information and incentives not only play an important role in the medical treatment process but in all medical decisions. A better understanding of their impact on decisions can help to design an environment in which desired outcomes such as higher patient benefits or welfare can be achieved. This thesis presents five studies investigating how information and incentives affect physicians' and patients' decisions.

Information and medical decision making

For any decision people need at least two alternatives to choose from. Therefore, decision makers should know that there are alternatives and, at best, have information about the alternatives at hand. For example, physicians should know available options and potential consequences when treating a patient. When choosing a new physician, patients should know what physicians have their practice nearby and if they admit new patients. Patients may also gather additional information by asking relatives or friends about their experiences with specific physicians. In general, information is the basis for decisions.

The quote by Arrow (1963) refers to information asymmetries which are prevalent in medical care. Due to their education and experience physicians typically know more about diseases and treatment options than patients themselves. Even after treatment, patients may not be able to verify if the treatment provided was necessary and the best option available. As with other expert services, the information asymmetry leaves room for undertreatment, overtreatment, and overcharging (Dulleck & Kerschbamer, 2006). More information for patients can then reduce the information asymmetry and thus the risk of such fraudulent behavior. One way to increase the information for patients is to reveal past behavior of physicians which may say something about their preferences and potentially their future behavior. For expert markets, experimental evidence on the effect of information about past rounds is mixed. While Huck, Lünser, Spitzer, and Tyran (2016) find less overtreatment when revealing experts' market shares, Dulleck, Kerschbamer, and Sutter (2011) find no effect on expert behavior when consumers observe how these experts treated them in past rounds.[1] In health economics experiments, revealing information to other physicians leads to better treatment quality (Godager, Hennig-Schmidt, & Iversen, 2016; Huesmann, Waibel, & Wiesen, 2020; Kairies & Krieger, 2013).

While past behavior of physicians could be an indicator for their underlying preferences and their future behavior, other information may be less relevant but still influence decisions. The primary form of conveying information between physician and patient is communication. As long as the interests of involved parties are aligned, communicated information is credible and may be useful for decision making. When interests are opposed though, non-binding communication should not influence decisions from a game theoretic point of view (see Crawford, 1998, for an overview). Numerous experimental studies provide evidence that communication can affect decision making.[2] For medical decision making and especially for decisions affecting patient outcomes, the influence of communication is not clear (see Ong, Haes, Hoos, & Lammes, 1995; Street, Makoul, Arora, & Epstein, 2009, for overviews). This may partly be due to the fact that it is necessary to control for other influential factors like patients' characteristics or physicians' incentives in order to identify pure effects of communicated information.

Incentives and medical decision making

Incentives motivate people to act or change their behavior. Typically, they are classified as intrinsic or extrinsic (e.g., Bénabou & Tirole, 2003). People are intrinsically motivated if they want to do something for its own sake. Physicians may, for example, provide treatment to patients because they are interested in their patients' well-being. Theoretical models take such an intrinsic motivation into account in the form of altruism (e.g., Chalkley & Malcomson, 1998;

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[1] Similarly, Mimra, Rasch, and Waibel (2016a) find no difference between information about own experiences and information about experiences of all consumers.

[2] For example, lab experiments show that communication can influence outcomes in bargaining (e.g., Brosig, 2006; Roth, 1995a), increase trust (e.g., Buchan, Johnson, & Croson, 2006; Charness & Dufwenberg, 2006) or cooperation (e.g., Brosig & Weimann, 2003; Bochet, Page, & Putterman, 2006).

Ellis & McGuire, 1986; Makris & Siciliani, 2013). Extrinsic motivation, on the other hand, arises from (financial) rewards or punishments that are dependent on behavior. In medical decision making, financial incentives exist in particular in the remuneration of physicians. As a simple remuneration, physicians can receive a lump-sum payment per patient (capitation payment) or a fee for each unit of medical services provided (fee-for-service payment). While the capitation payment incentivizes physicians to provide less medical treatment than optimal, the fee-for-service payment rewards the provision of too much treatment (Ellis & McGuire, 1986).[3] Bonus payments (see, e.g., Brosig-Koch, Henning-Schmidt, Kairies-Schwarz, Kokot, & Wiesen, 2019; Eijkenaar, Emmert, Scheppach, & Schöffski, 2013) or kickbacks (Amann & Felder, 2021) may help incentivizing more patient-oriented or efficient behavior of physicians. Patients also need to consider financial consequences, for example when choosing insurance. The conclusion of an insurance policy is associated with costs. If the insured event, e.g. need for a specific treatment, occurs, patients usually save money because the insurance company covers the costs for treatment (to the extent of the insurance).

When behavior can be regarded as prosocial, reputational motivations are also important for decision making (Bénabou & Tirole, 2006). People follow social pressure or norms and do good deeds to be perceived as good by others or to maintain a certain self-image. Such reputational incentives may apply to health-related behavior like eating healthy food or doing sports when it is shared with other people on social media, for example. For physicians, reputational concerns become relevant if the quality of treatment decisions is revealed to others. Such public information on physicians' performance can improve treatment quality according to empirical studies (e.g., Cutler, Huckman, & Landrum, 2004; Kolstad, 2013) and laboratory experiments (Godager et al., 2016; Huesmann et al., 2020; Kairies & Krieger, 2013).

Although incentives work in general, the interplay of different motivations may lead to other outcomes than each of the involved incentives applied individually. In particular, monetary incentives may crowd out intrinsic or reputational incentives in the short and/or long run (see Gneezy, Meier, & Rey-Biel, 2011, for an overview). One explanation is that monetary incentives may convey information and thus influence the perception of a task. For example, the introduction of financial incentives can shift the framing of a decision situation from social

[3] Although empirical evidence on the effect of these payment schemes is mixed (e.g., Gaynor & Gertler, 1995; Gosden et al., 2001; Clemens & Gottlieb, 2014), laboratory experiments show that capitation leads to an underprovision and fee-for-service to an overprovision of medical services (e.g., Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, & Wiesen, 2016, 2017; Hennig-Schmidt, Selten, & Wiesen, 2011).

to monetary and thus reduce reputational motivations (e.g., Gneezy & Rustichini, 2000; Heyman & Ariely, 2004). It is therefore important to study how specific incentives work in a particular context.

The method of laboratory experiments

In order to study the impact of information and incentives on medical decisions, it is necessary to control for the information available to decision makers and for the incentives they are exposed to. This is very hard to achieve in the field – if possible at all. The laboratory, on the other hand, offers tight control over the decision environment and the variables of interest. This enables researchers to investigate how a specific variable influences the decisions of participants ceteris paribus (see, e.g., Fréchette & Schotter, 2015, for a discussion of the experimental method).

Although the use of experiments in health economics has been proposed some time ago (Frank, 2007; Fuchs, 2000), it is only in recent years that laboratory experiments have become an accepted method in health economics (Galizzi & Wiesen, 2018). Following Roth (1995b), experiments can be conducted for three purposes: testing theories, finding causalities for observed regularities, and giving policy advice. Health economists can use lab experiments for all three purposes.

The first category – testing theories – aims at testing the predictions of precisely formulated theories in experiments specifically designed for this purpose. This has been done since the beginning of the 20th century, when experiments were conducted to investigate individual choices and to test game theoretic hypotheses (see Roth, 1995b, and Roth, 2015, for an overview on the development of experimental economics). In health economics, the test of specific theoretical models is very difficult to achieve with field data – if not impossible at all. In contrast to the field, the lab environment allows researchers to control for the variables of interest and possible confounding factors. For example, patient characteristics can be implemented explicitly and varied systematically while they may only be reported subjectively in field data. Also, several policy interventions could be introduced at once in the field, making it difficult to disentangle effects (Galizzi & Wiesen, 2018). Lab experiments, on the other hand, can help to determine the effect of specific influences like a change in incentives.

The second purpose – finding causalities for observed regularities – is to further investigate behavioral regularities which are often observed but not yet covered in a well-formulated theory. Experiments can then help to identify under what circumstances the behavioral patterns occur and thus to formulate a theory. Prominent examples are the development of Prospect Theory (Kahneman & Tversky, 1979) or theories on other-regarding behavior (Bolton & Ockenfels, 2000; Charness & Rabin, 2002; Fehr & Schmidt, 1999). With respect to healthcare, experiments can be conducted to investigate phenomena like teamwork between physicians from various specialties or the use of heuristics in decision making (Hansen, Anell, Gerdtham, & Lyttkens, 2015).

Experiments of the third category – giving policy advice – allow for conclusions relevant for policy makers, e.g. the effect of an institution change. As decisions related to healthcare not only have economic consequences but also consequences for patients' health, the stakes are high. Thus, it is particularly important to understand how influencing factors affect outcomes in order to design institutions in the right way. Due to methodological or ethical reasons, it is hard to control for these factors – especially information – in the field. Lab experiments can then serve as a testbed for institutional changes. In the area of market design, experiments have been used for example to study matching mechanisms for the US medical labor market (Roth, 2002) or a kidney exchange system (Roth, Sönmez, & Ünver, 2007).

Although laboratory experiments are a widely accepted method in economic research, they still face criticism. The main concern is about external validity, i.e., that results may not be transferrable to other contexts or the field (Levitt & List, 2007a, 2007b; Schram, 2005). It depends however on the research question and the variables of interest which research method – lab or field experiment for example – suits best for identifying the effects of interest. Due to the tight control over the decision environment, lab experiments are a useful tool to isolate causal relationships. Therefore, they complement other methods like theories and field experiments in gaining knowledge about decision behavior (Falk & Heckman, 2009). Part of the concern with respect to external validity is the question if decisions made by participants – usually students – can say something about how people decide in situations relevant for the research question. For health economics experiments, this especially applies to physician behavior. Are decisions from student participants comparable to those that physicians make? As a first approach to answer this question, studies analyze whether prospective physicians, i.e. medical students, behave similarly as a regular participant pool for experiments consisting of students from various fields of study. These studies typically find that both groups react similarly to incentives. However, the intensity of behavioral responses differs between groups (Brosig-Koch, Hennig-Schmidt, et al., 2017; Hennig-Schmidt & Wiesen, 2014). As a next step, studies investigate if actual physicians decide similarly as (medical) students in a comparable decision environment. Their findings indicate that physicians respond to experimental variations in the same direction but less intense than (medical) students (Brosig-Koch et al., 2016; Reif, Hafner, & Seebauer, 2020; Wang, Iversen, Hennig-Schmidt, & Godager, 2020). These observations support the validity of laboratory experiments for qualitative behavioral responses of real physicians even when students from various fields of studies take part. Nevertheless, one should be cautious calculating effect sizes.

In order to isolate the effects of interest, experiments typically simplify a complex decision situation from the real world and present it in a more abstract setting. Since an abstract framing leaves no control over participants' perceptions of the decision task (Harrison & List, 2008), most health economics experiments apply a medical framing (e.g., Brosig-Koch et al., 2016; Brosig-Koch, Hehenkamp, & Kokot, 2017; Brosig-Koch, Hennig-Schmidt, et al., 2017; Hennig-Schmidt et al., 2011). Some experiments nevertheless use a neutral frame (e.g., Green, 2014; Huck et al., 2016; Mimra et al., 2016a, 2016b). So far, only few studies compare neutral and medical frames resulting in mixed evidence. While Ahlert, Felder, and Vogt (2012) find that participants' decisions differ between both frames, Kesternich, Schumacher, and Winter (2015) observe no significant differences in general.

A further deviation from reality is that medical decisions often have consequences for patients' health which cannot be directly implemented in the lab. Researchers instead express the health benefit from treatment decisions in monetary terms. Depending on the experimental design, there may be participants in the role of patients in the lab or not.[4] When no participants are in the role of patients (as in, e.g., Brosig-Koch, Hennig-Schmidt, et al., 2017; Hennig-Schmidt et al., 2011), the patient benefit resulting from decisions in an experiment can be donated to a charitable organization which uses the donation to the benefit of real patients outside the lab like the Christoffel Blindenmission (e.g., Brosig-Koch et al., 2016; Brosig-Koch, Hehenkamp, & Kokot, 2017; Hennig-Schmidt et al., 2011) or Ärzte der Welt (e.g., Brosig-Koch, Griebenow, Kifmann, & Then, 2022). In order to validate the actual transfer of the money, many

[4] One important aspect for the decision to have participants in the role of patients or not is if the research question requires patients to make decisions.

experiments follow Hennig-Schmidt et al. (2011) and employ a monitoring process as suggested by Eckel and Grossman (1996).[5] When there are participants in the role of patients (as in, e.g., Ahlert et al., 2012; Brendel, Einhaus, & Then, 2021; Brosig-Koch, Imcke, & Then, 2022), they simply receive the patient benefit as (part of) their experimental payment.

For the five studies presented in this thesis, the experimental method is particularly well suited. The controlled environment makes it possible to test theoretical predictions or to investigate behavioral regularities related to the role of information and incentives in medical decision making. Therefore, all five studies use lab experiments to shed some light on the particular research question.

Overview of the five studies

Given that little is known about the effect of information on medical decisions, especially on decisions by patients, chapter 1 and 2 focus on how information influences patients' decisions. In **chapter 1**[6], we investigate if information about the past influences the choice to insure oneself against a bad event. In a lab experiment, participants state the price at which they want to buy or sell insurance. Afterwards, a wheel of fortune determines whether the bad event occurs and causes a substantial loss for uninsured participants. Participants are informed about the probability with which the bad event occurs. Moreover, they gain information about past events, i.e., they saw at which position the wheel of fortune stopped in previous rounds. In the market condition and in the condition with social information but random price setting, they can also observe other participants' preferred buying or selling prices. While information about others' evaluations of the insurance may be strategically relevant in the market condition, it should be irrelevant for the decision to insure oneself when the price is set randomly.

Although events in the past do not influence the probability for the bad event, we observe that they influence decisions when participants can observe others' evaluations of the insurance. Participants significantly increase their willingness to pay for the insurance in the market condition after a loss almost happened. We find no significant difference between the market condition and the condition with social feedback and random price setting. Thus, the higher

[5] A monitor is selected randomly from the participants and ensures that the correct amount of money is written on a check or bank transfer form. The check or form is then sealed in a correctly addressed envelope which is deposited in the nearest mailbox by the monitor and an experimenter.
[6] Heinrich, T., Seifert, M., & Then, F. (2020). Near-losses in insurance markets: An experiment. *Economics Letters, 186,* 108781. https://doi.org/10.1016/j.econlet.2019.108781

willingness to pay for insurance may be at least in part attributable to the information about other participants' evaluations of the insurance. Although the experiment is framed neutrally, its conclusion is also applicable to patients' choice of insurance when health insurance is not mandatory or when they can choose supplementary insurance against cases not covered by their regular insurance. Such voluntary (supplementary) insurances are usually traded in markets. The study presented in chapter 1 shows that patients' willingness to pay for voluntary insurance may be influenced by past events, especially when a bad event almost occurred.

As chapter 1 reveals the influence of past events on patients' choice of insurance, we investigate if this also applies to patients' choice of physician in the study presented in **chapter 2**[7]. When choosing between two physicians, participants in the role of patients can observe physicians' previous treatment decisions in conditions with reputation information in the experiment. Furthermore, physicians have the opportunity to communicate non-binding information to patients in conditions with physician messages. In a control condition, patients observe only their travel costs to physicians (as in all conditions). Our theoretical model shows that the availability of reputation information should affect decisions of patients and physicians if physicians' altruism parameters are heterogeneous. Previous treatment decisions can signal physicians' altruism and thus also their future provision behavior. This allows physicians to strategically improve their reputation and increase their chance of being chosen for treatment. In contrast, information communicated by physicians in messages should be irrelevant for decision making without further assumptions.

In line with the theoretical considerations, we observe that, on average, physicians provide better treatment in conditions with reputation information. In these conditions the treatment quality drops significantly in the last round, further indicating strategic decision making by physicians. Also as predicted, patients prefer physicians with lower travel costs and, if reputation information is available, with higher previous treatment qualities. With respect to communicated information, patients rather choose physicians who promise to provide a specific quality. When no information about physicians' past behavior is available, patients also prefer physicians who write a message (instead of sending an empty message) and physicians whose messages increase social proximity. Our results show that patients benefit from the availability

[7] Brosig-Koch, J., Imcke, P., & Then, F. (2022). *The Role of Communication and Reputation Information in Patients' Choice of a Physician*. Working paper available at SSRN. https://doi.org/10.2139/ssrn.4271233

of reputation information, while physicians' opportunity to send messages to patients does not affect patient benefit.

Although chapter 2 focuses on patient decisions, it also demonstrates how reputation information motivates physicians to provide better patient treatment. Chapters 3 to 5 focus solely on decision making of physicians. While previous studies already show that financial incentives matter, e.g. in the form of capitation payment, the study presented in **chapter 3**[8] takes a closer look at how the size of a capitation payment influences physician provision behavior. The lab experiment is designed as a three-person dictator game with varying budgets over several rounds. Participants in the role of physicians can allocate resources to two other participants in the role of patients. This implies a trade-off between physicians' profits and patients' health benefits as well as between several patients' benefits. Patient benefits increase with allocated resources, although the increase may differ between rounds and between both patients in a group. This design feature allows us to distinguish between four allocation principles for physicians' decisions: allocating nothing to patients (selfishness), providing equal patient benefits (equal outcomes), allocating the same quantity of services to both patients (equal resources), and allocating more to the patient with a higher increase in benefit (efficiency).

We observe that most physicians devote a relatively stable share of their budget to patient treatment. Thus, they provide lower patient benefits when resources are scarcer. With respect to the distribution of resources between both patients, the majority of participants in the role of physicians chooses an allocation leading to equal benefits. On average, patient benefits decrease in proportion to physician budgets. Despite a considerable degree of non-selfish decisions, this study indicates that a change in the size of a physician's budget may lead to a proportional shift in patients' health outcomes.

Chapter 4[9] extends the setting from chapter 3 to study whether physicians' decisions are influenced by communicated information - as observed for patients' decisions in chapter 2. In particular, the lab experiment from chapter 3 is extended with the opportunity for patients to send a text message to their physician prior to decision making in each round. Patients'

[8] Brendel, F., Einhaus, L., & Then, F. (2021). Resource scarcity and prioritization decisions in medical care: A lab experiment with heterogeneous patient types. *Health Economics, 30*(2), 470–477. https://doi.org/10.1002/hec.4192

[9] Then, F. (2022). *Write something: An experiment on patient messages and physician provision behavior*. Unpublished working paper.

opportunity to write free-form text messages allows to study the influence of the messages per se and of specific message contents, i.e. specific information provided by patients. As the messages do not affect payment, they should theoretically be irrelevant for decision making under the assumption of rationality and selfishness though.

On average, the communication opportunity does not significantly influence patient benefits. A closer look shows however that physicians allocate less resources to patients who send an empty message compared to patients writing a message. A possible explanation for this discrimination of silent patients could be that physicians reciprocate patients' reluctance to put effort in writing a message. An analysis of the effect of message contents shows that specific message contents influence treatment decisions depending on patient type. Requesting a benefit is detrimental for stronger patients. Weaker patients benefit from increasing social proximity to female physicians. These findings reveal an influence of patient messages on physician decisions. Seemingly, the messages convey information about the patients which motivates physicians to provide other benefits.

While chapter 3 shows that financial incentives and their size matter for physicians' treatment decisions, we investigate whether financial incentives can improve the collaboration between physicians in patient referrals in **chapter 5**[10]. More precisely, we investigate if bonus payments can improve the information flow between physicians and consider the situation of a primary care physician (PCP) deciding on the provision of low- or high-quality information to a specialist. Thus, information becomes the dependent variable in this study. Our theoretical model takes altruism and an aversion to losses from a reference point into account in the PCP's utility function. The model provides an explanation for insufficient information provision in patient referrals. As a remedy for the underprovision of information, we consider a bonus payment for information provision. Based on our model, we develop theoretical predictions on how information transfers change if the payment exceeds thresholds relating to the cost of low- and high-quality information provision. We test our predictions in a controlled lab experiment. Experimental conditions vary with regard to who benefits from information provision (patient vs. specialist), who has higher earnings (PCP vs. specialist/patient), and whether the bonus payment is introduced cost neutrally (yes vs. no).

[10] Brosig-Koch, J., Griebenow, M., Kifmann, M., & Then, F. (2022). Rewards for information provision in patient referrals: A theoretical model and an experimental test. *Journal of Health Economics*, *86*, 102677. https://doi.org/10.1016/j.jhealeco.2022.102677

In line with our theoretical predictions, PCPs provide more low- and high-quality information as the bonus payment increases. If the bonus payment covers the costs for high-quality information provision, PCPs pass on more information of high quality and less information of low quality compared to decision tasks with lower bonus payments. The observed behavioral pattern is in line with our model considering an aversion to losses in addition to altruism. Moreover, PCPs react similarly to increases in the bonus payment regardless of whether the bonus payment is introduced cost neutrally or not. The beneficiary from information provision only matters when specialists and patients have higher earnings than PCPs. Then, PCPs mainly focus on their own profit and provide less high-quality information when specialists benefit from information provision than when patients benefit from information provision.

The three key findings of this thesis emphasize the role of information and incentives for medical decisions: First, information about the past and communicated information affect patients' decisions, second, financial incentives and their size are relevant for physician behavior, and, third, communicated information also influences physicians' decisions.

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Chapter 1

Near-losses in insurance markets: An experiment

Reference

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Near-losses in insurance markets: An experiment[☆]

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Several studies report changes in risk taking subsequent to experiencing near-loss events. We disentangle strategic and non-strategic reactions to such near-losses experimentally. We observe that near-losses affect the supply and demand for insurance under strategic uncertainty but not individual evaluations.

1. Introduction

The decision to insure against potential disasters results at least partially from whether decision makers have "nearly averted" personal damage previously. Kunreuther et al. (1978) presented field data suggesting that individuals who experience events in which, by good fortune, no flood damage is incurred, subsequently increase their willingness to take risks by allowing insurance policies to lapse. More recently, similar reactions to near-losses are reported in vignette studies on space missions (Dillon and Tinsley, 2008), cyber-attacks (Rosoff et al., 2013) and flood and hurricane risks (Dillon et al., 2011).

The cost of insuring against a loss is usually determined by supply and demand in a market. Since most markets are not perfectly competitive, strategic incentives will arise. If near-losses do not reveal new information about the size of the loss or its likelihood, rational market participants will have no reason to adjust their evaluations of the respective insurance. Their strategic bids or asks are also expected to remain unaffected, as long as the rationality of the market participants is common knowledge. If common knowledge is absent, however, the belief that the bids or asks of others may change after observing a near-loss will be enough to change bids or asks (or the belief that others believe that someone's bids or asks may change, or that others believe that someone believes that someone's bids or asks may change, and so on). The previous literature does not consider such strategic uncertainty even though it has been shown to be crucial for interaction in markets (see for example Crawford and Iriberri, 2007; Charness and Levin, 2009, on auction behavior).

In our experiment we aim to disentangle non-strategic reactions to near-losses from reactions that are driven by strategic uncertainty. We confront subjects with a lottery gamble that may lead to a sizeable loss. There is transparency with regard to the size and the likelihood of the loss. We elicit valuations for insurance that protects subjects from the potential loss using the incentive-compatible BDM mechanism (Becker et al., 1964), which is commonly used to elicit evaluations of insurance contracts (see Jaspersen, 2016, for a survey). We compare these evaluations to bids and asks for the insurance in an open-book call market.

Prices for the insurance in the BDM mechanism are determined by a bid from a random number generator, while prices in the call market are the result of asks and bids chosen by other human market participants. As in the BDM mechanism, bids and asks in the call market will be driven by each individual's evaluation of the insurance. In the call market, however, they are also

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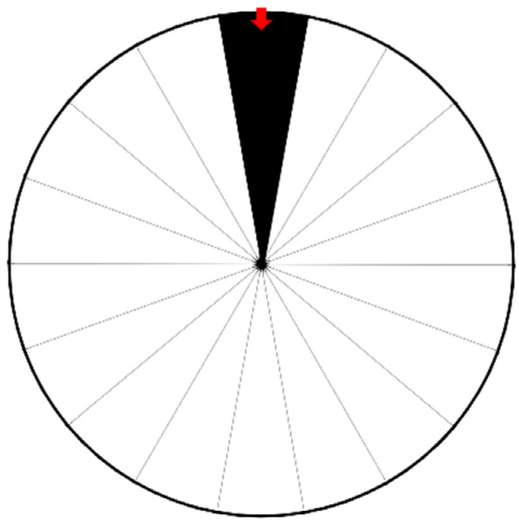


Fig. 1. Roulette wheel with 18 fields.

influenced by strategic uncertainty about the behavior of other market participants. Comparing risk taking in both conditions allows us to identify the effect of strategic uncertainty on the reactions to near-losses. We also run an open-book version of the BDM mechanism. As in the call market, there is the potential for social influence among market participants but there is no strategic uncertainty.

Recent experimental studies on asset markets have revealed that a lack of common knowledge about rationality drives the mispricing of assets. Cheung et al. (2014) observe that mispricing is substantially reduced if market participants know that all market participants have been trained extensively on the nature of the fundamental value. Training itself, however, does not affect mispricing. Akiyama et al. (2017) also study behavior in experimental asset markets. They compare the behavior of individuals facing other human traders to the behavior of individuals facing computerized traders known to behave rationally. They conclude that 50 percent of the observed mispricing was driven by strategic uncertainty caused by human traders. In an incentivized experiment conducted in parallel to our study, Wu et al. (2017) observe less risk-averse behavior after near-losses in a non-strategic betting task. Like Wu et al. (2017), we use a roulette wheel to provide participants with event cues and for resolving uncertainty (see also Kahneman and Varey, 1990, for an early discussion).

2. Experimental design

In the experiment insurance contracts against the lottery X could be traded in rounds $t = 1, \ldots, 18$. The binary lottery pays -18 experimental currency units (ECU) with a probability of 1/18 and 0 otherwise. This lottery was depicted as a roulette wheel in the experiment shown in Fig. 1 (see Appendix A for complete instructions): one field yields a loss of 18 ECU while the other 17 fields do not influence payoffs. After each round the outcome of the lottery was determined by an animated wheel spin (as depicted) that highlighted which field was selected in a particular round. The loss event occurred when the wheel stopped on the black field. A near-loss event was operationalized in terms of the two fields adjacent to the black field.

At the beginning of the experiment subjects were randomly assigned the role of a buyer or seller. In each round, sellers were endowed with an insurance contract against the lottery, while buyers were not. The lottery had an expected payoff of -1 ECU which is equal to the fair value of the insurance contract. Each round started with an actuarially equal distribution of endowments: buyers were endowed with 26 ECU and sellers with 25 ECU. Across treatments buyers stated the highest price for which they were willing to buy insurance ("bid") and sellers stated the lowest price for which they were willing to sell insurance ("ask"). Once a trade was implemented the price was subtracted from the buyer's endowment and added to the endowment of the respective seller. Subjects could hold at most one insurance contract. Those who did not hold a contract at the end of a round had to play the lottery, and any resulting loss was subtracted from their payoff for that round. At the end of the experiment one round was randomly determined for payment and ECU were converted to Euros at a rate of ECU 1 to Euro 0.80.

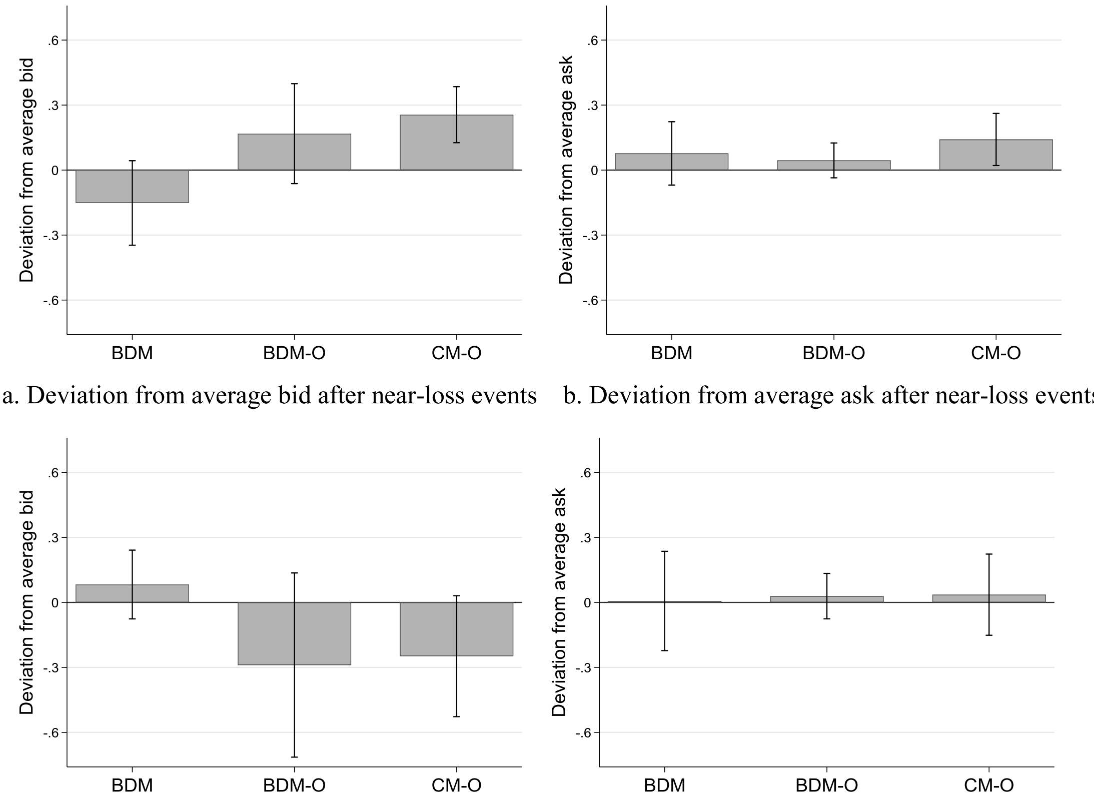
Table 1 summarizes the treatments. In two treatments we used the incentive-compatible BDM mechanism (Becker et al., 1964). In theory, this mechanism truthfully elicits the individual willingness-to-pay (WTP) and willingness-to-accept (WTA) of buyers and sellers.[1] More specifically, in the two BDM treatments, **BDM** and **BDM-O,** subjects had to enter the highest price for which they would buy insurance or the lowest price for which they would sell the insurance. These values were elicited using a list of potential prices, as in Bartling et al. (2015). Subjects were informed that one of the prices would be selected randomly as the clearing price. Buyers would buy the insurance if their stated bid was higher or equal to this price. Sellers would sell the insurance if the ask was equal to or below this price. The two BDM treatments were framed as a market interaction, but buyers and sellers submitted their values in the BDM mechanism privately and the outcome was determined independently for everyone. Participants in the **BDM** treatment were not informed about the actions of other participants. In the **BDM-O** treatment subjects were informed at the end of each round about the bids and asks entered by the other subjects in a matching group. Subjects in this treatment interacted in groups of eight market participants (without re-matching), equally divided into buyers and sellers. The feedback provided meant that this represented an "open-book" version of the BDM mechanism.

In the **CM-O** treatment we implemented the open-book call market (Arifovic and Ledyard, 2007). In this treatment participants also interacted in groups of eight market participants. Bids and asks were collected as sealed-bids and the market price was determined by maximizing the feasible number of trades in each round. As in the **BDM-O** treatment, participants were informed about all bids and asks in their market after each round. Note that bids and asks are the result of strategic interaction in this treatment, and cannot be regarded as willingness-to-pay or willingness-to-accept measures. Nevertheless, we can compare the adjustments of bids in **BDM**, **BDM-O** and **CM-O** over time.

All subjects participating in one matching group faced the same lottery realizations. Two orders of independent lottery realizations were used across treatments. On average, each subject experienced two near-losses and one loss in total.

Sessions lasted for 90 min at most and subjects earned 19.93 Euros on average. They were recruited via ORSEE (Greiner, 2015). The eight sessions were conducted at the Essen Laboratory for Experimental Economics (elfe) using z-Tree (Fischbacher, 2007). In each session we conducted all three treatments at a time and participants were randomly assigned to treatments.

[1] Since the lottery we consider has a negative expected value, buyers buy insurance and state their willingness-to-pay (WTP), while sellers state their willingness-to-accept (WTA) (see Camerer and Kunreuther, 1989, for a similar wording). Of course, referring buyers of the insurance as "sellers of the lottery" would be equivalent.



a. Deviation from average bid after near-loss events b. Deviation from average ask after near-loss events

c. Deviation from average bid after loss event d. Deviation from average ask after loss event

Fig. 2. Deviation from average bids or asks after near-loss and loss events with 90% confidence intervals.

Table 1
Treatments.

Treatment	Price determination	Feedback	Rounds	Matching groups	*N*
BDM	BDM list	None	18	–	32
BDM-O	BDM list	Order book	18	8	64
CM-O	Call market	Order book	18	8	64

3. Results

In accordance with an endowment effect which is frequently observed in experimental studies (for studies involving lotteries see, e.g., Knetsch and Sinden, 1984; Eisenberger and Weber, 1995; Schmidt and Traub, 2009), buyers' average bid (2.219) was higher than sellers' average ask (4.048). In line with risk aversion, the average bids and asks were significantly larger than one (the fair price of the insurance) in all three treatments ($p \leq 0.030$, two-sided Wilcoxon matched-pairs signed-ranks tests). The average ask is 0.427 ECU higher in **BDM** than in **CM-O** ($p = 0.037$, two-sided Mann–Whitney-*U* test). There were no other significant differences in bids or asks between treatments ($p \geq 0.159$).

If subjects adjust their individual evaluations of the insurance after near-loss or loss events, we should observe a change in buyers' bids and sellers' asks in all treatments. If changes are due to strategic considerations, they should only occur in the treatment with market interaction, **CM-O**.

Fig. 2 shows the deviation in bids and asks after near-loss and loss events compared to the average bid or ask in rounds not following a near-loss or loss event. We observe a significant increase in buyers' bids in **CM-O** of 0.256 ECU after experiencing near-loss events, indicating a decrease in risk taking ($p = 0.025$, two-sided Wilcoxon matched-pairs signed-ranks tests). Similarly, sellers exhibit weakly significantly less risk taking by stating asks which are on average 0.141 ECU higher after near-loss events ($p = 0.068$). We do not find significant changes in risk taking behavior in **BDM** and **BDM-O** ($p \geq 0.162$). After observing a loss, only buyers in **CM-O** decreased their bids weakly significantly ($p = 0.093$). Although the change in bids is not significant for buyers in **BDM-O** ($p = 0.263$), its tendency is similar to that in **CM-O**. Other subjects did not adjust their bids or asks following a loss ($p \geq 0.461$).

We also run separate fixed effects panel regressions for buyers and sellers in each treatment. We assume that buyers i in a matching group j state their bid in round t according to

$$bid_{it} = \beta_0 + \beta_1 price_{j,t-1} + \beta_2 near\_loss_{j,t-1} + \beta_3 loss_{j,t-1} + \alpha_i + \varepsilon_{it}. \quad (1)$$

The bidding function contains the last round's price ($price_{j,t-1}$) which may serve as an anchor for bidding in the current round t. The two dummy variables $near\_loss_{j,t-1}$ and $loss_{j,t-1}$ take the value 1 if buyers and sellers in market j experienced a near-loss event or loss event, respectively, in the last round and 0 otherwise. Idiosyncratic errors ε_{it} are assumed to be independently and identically distributed. We apply the same model for sellers' asks and only replace each "bid" with "ask" in (1). Table 2 shows the results.

Consistent with our non-parametric tests, regressions show an increase in bids and asks – or a decrease in risk taking – after experiencing near-loss events in **CM-O,** but not for buyers' and sellers' evaluations in **BDM** and **BDM-O**. This suggests that the strategic uncertainty of the market environment drives behavioral responses to experiencing near-loss events. The increase in average bids subsequent to near-losses is in fact significantly greater for buyers in **CM-O** than in **BDM** ($p = 0.006$, two-sided Mann–Whitney-*U* test). Since there are no significant differences between **CM-O** and **BDM-O** ($p = 0.528$), however, the decrease

Table 2
Regressions for buyers' bids and sellers' asks.

	Buyer			Seller		
	BDM (1)	BDM-O (2)	CM-O (3)	BDM (4)	BDM-O (5)	CM-O (6)
$price_{j,t-1}$	0.014	0.007	0.090**	0.030	0.055**	0.016
	(0.032)	(0.031)	(0.041)	(0.020)	(0.022)	(0.051)
$near\_loss_{j,t-1}$	−0.149	0.168	0.233**	0.084	0.044	0.137*
	(0.114)	(0.118)	(0.095)	(0.084)	(0.052)	(0.075)
$loss_{j,t-1}$	0.093	−0.294*	−0.259	0.028	−0.009	0.034
	(0.092)	(0.168)	(0.186)	(0.122)	(0.080)	(0.102)
Constant	2.004***	2.400***	2.106***	4.147***	3.758***	3.756***
	(0.091)	(0.065)	(0.138)	(0.052)	(0.048)	(0.171)
Observations	272	544	544	272	544	544
Number of subjects	16	32	32	16	32	32
F-test	1.165	1.674	3.376	3.740	3.030	1.285
Prob>F	0.356	0.193	0.0307	0.0345	0.0441	0.297
BIC	433.7	1508	1160	295.8	978.5	1212

Notes: Robust standard errors are reported in parentheses.
***$p<0.01$.
**$p<0.05$.
*$p<0.1$.

in risk taking in **CM-O** may be at least in part attributable to feedback about other bids and asks in the market (see, e.g., Trautmann and Vieider, 2012, for a survey on social influences on risk taking).

The tendency for less risk taking following a near-loss in **CM-O** appears to contradict previous work by Dillon and Tinsley (2008) as well as by Tinsley et al. (2012), who observe an increase in risk taking subsequent to experiencing near-loss events. However, studies conducted in these papers are substantially different as they rely on hypothetical, vignette-based decision scenarios and do not consider social influences or strategic uncertainty.[2] Taking this into account, our findings are broadly consistent with previous results by Wu et al. (2017). Focusing only on individual decisions, the authors also employ an incentivized task using a roulette wheel. They observe more risk-averse behavior if the roulette wheel stops just *before* the loss and less risk-averse behavior if it stops just *after* the loss. The near-losses in our experiment resemble their "before near-loss" conditions. This was not a conscious design-choice but resulted from the specific time-series of random spins generated in our experiment.

4. Conclusion

To our knowledge we present the first study analyzing near-loss events using the tools of experimental economics. Our experiment reveals that strategic uncertainty influences risk taking subsequent to experiencing near-losses. In our setting, we do not observe a significant effect from near-losses on individual evaluations of insurances as measured using the BDM mechanism. However, we observe an increase in bids for insurances and – to a smaller degree – an increase in asks in a call market with strategic uncertainty. It is important to note that this effect may also be influenced by competitiveness or other aspects that are specific to a market setting, however. Although not significant, we find a tendency for a similar effect when allowing for social influences among participants when eliciting individual evaluations using the BDM mechanism. This finding suggests that also social information may contribute to the decrease in risk taking we observe in the call market.

2 Moreover, Tinsley et al. (2012) distinguish between two types of events: Near-loss events that almost happened may increase the perceived vulnerability of a system and, hence, lead to less risk taking, whereas near-loss events that could have but did not happen may increase the perceived resilience of a system and, hence, result in more risk taking. It remains speculative, however, whether the near-loss event in our study was indeed interpreted by our subjects as an event that "almost happened".

Appendix A. Instructions

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.econlet.2019.108781.

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Appendix: Instructions (translated from German)

Welcome to the experiment!

Preliminary note

You are taking part in an experiment about decision making. During the experiment you and the other participants will be asked to make decisions. By doing so, you can earn money. How much you are about to earn depends on your decisions. After the experiment you will receive your earnings in cash.

None of the participants will receive any information concerning the identity of other participants during the experiment.

Instructions

Please read the following instructions carefully. Approximately five minutes after you have received the instructions, we will come to your desk to answer any remaining questions. Should you have any questions during the experiment, please raise your hand. We will then come to your desk to answer them.

Procedure

The experiment consists of 18 rounds. One of these rounds will be randomly selected at the end of the experiment to determine your payoff. In each round you own an amount of money that can be reduced by participating in a lottery. You always have to participate in the lottery but you can insure yourself against the potential loss of a round. If you are insured, you will not suffer a loss through the lottery of this round in any case.

At the beginning of the experiment it will be randomly determined whether you participate as a buyer or seller. In each round the sellers own a budget of 25 experimental currency units (ECU) and one insurance policy. The buyers own a budget of 26 ECU and no insurance policy. If the lottery results in a loss, it reduces the budget of each participant not owning an insurance policy by 18 ECU.

One round consists of a *trading phase* and a *lottery phase*. In the *trading phase* insurance policies can be bought or sold. In the *lottery phase* a spin of a wheel of fortune determines whether a loss occurs.

Trading phase

At the beginning of each round insurance policies against a loss from the lottery can be traded on a market. Sellers own one insurance policy each at the beginning of a round. In the trading phase they have to state whether they would sell their insurance policy at various potential price levels. Buyers do not own an insurance policy at the beginning of a round. In the trading phase they have to state whether they would buy an insurance policy at various price levels.

[*BDM/BDM-O:* In each round a new market price is drawn randomly from the interval 0 ECU to 5 ECU (including the values of 0 ECU and of 5 ECU). So note that you cannot influence the market price through your decisions.]

[*BDM-O/CM-O:* In each round you and seven other experiment participants will form a group consisting of four buyers and four sellers. The constellation of the group is determined randomly and remains the same for all rounds.] [*CM-O:* The market price is based on the lowest acceptable prices of sellers and on the highest acceptable prices of buyers. It is determined so that the largest possible number of insurance policies is traded between the buyers and sellers of your group. This happens under the condition that each participant can only own one insurance policy at the end of the trading phase. So note that you can influence the market price of your group through your decisions. (In the info-box on the last two pages of these instructions you will find further information about how exactly the market price is determined.)]

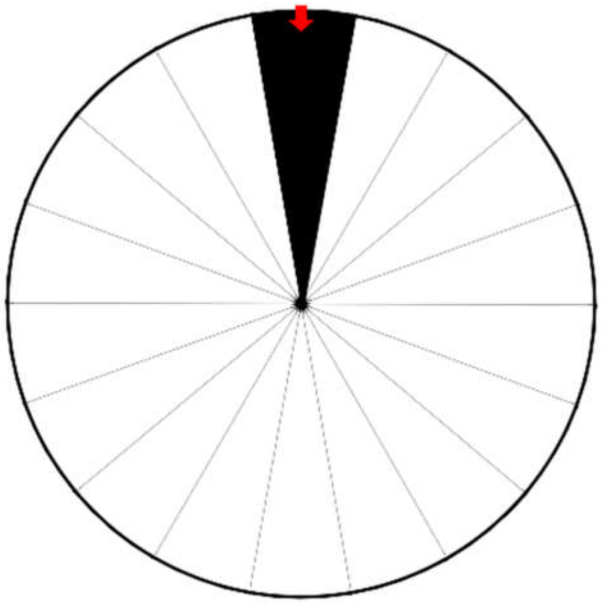
At the end of the trading phase you will be shown the market price. A trade will be realized if you have stated that you would buy or, respectively, sell an insurance policy at this price.

[*BDM-O/CM-O:* Also you will be shown an overview of the lowest acceptable prices of the four sellers and the highest acceptable prices of the four buyers in your group (ordered by size).]

Lottery phase

In the lottery phase a lottery will determine whether a loss occurs in each round, respectively. For this, a wheel of fortune such as the one in the figure below will be spun. The wheel of fortune has 18 fields, 1 black and 17 white. The wheel of fortune randomly stops at one of these 18 fields with each field being equally likely.

If the wheel of fortunes stops with a white field at the top, no loss occurs. That means the loss from the lottery is 0 ECU. If the wheel of fortune stops with a black field at the top, a loss 18 ECU occurs. The loss from the lottery is only relevant for experimental participants who do not own an insurance policy after the trading phase.



Profit calculation

After the lottery phase, the profits from a round will be calculated as follows:

- for a seller with insurance policy: 25 ECU
- for a seller without insurance policy: 25 ECU + market price – loss from the lottery
- for a buyer with insurance policy: 26 ECU – market price
- for a buyer without insurance policy: 26 ECU – loss from the lottery

Payment

At the end of the experiment one of the 18 rounds will be chosen at random and you will be paid the profit that round. 1 ECU amounts to 0.80 Euro. Payments are rounded to 0.10 Euro.

Before the first round you will participate in a short comprehension test. If you have any questions, please just raise your hand.

[*CM-O:* **Further information on the determination of the market price**

For calculating the market price all highest acceptable prices of buyers and all lowest acceptable prices of sellers will be determined first. They will then be ordered according to their size. If the highest acceptable price of all buyers is above the lowest acceptable price of all sellers, the respective buyer and the respective seller trade. If the *second* highest acceptable price of buyers is above the *second* lowest acceptable price of sellers, both market participants trade as well. The same principle applies to the third and fourth buyer-seller-pair.

So the total number of traded insurance policies is equal to the number of highest acceptable prices of buyers that are above lowest acceptable prices of sellers. Accordingly, in the market with four buyers and fours sellers at most four insurance policies can change hands.

If *none* of the highest acceptable prices of buyers is above the lowest acceptable prices of sellers, no trade takes place and there is no market price.

If *all* of the highest acceptable prices of buyers are above the lowest acceptable prices of sellers, all insurance policies will change hands. Then the market price is the average of both acceptable prices of the last trading buyer-seller-pair.

If *one*, *two* or *three* of the highest acceptable prices of buyers are above the lowest acceptable prices of sellers, one, two or three insurance policies will change hands. In this case, the market price will be determined as the average of the following two values:

(i) The lower of the following two values: The highest acceptable price of the last successful buyer and the lowest acceptable price of the first seller, who did not get to trade.
(ii) The higher of the following two values: The lowest acceptable price of the last successful seller and the highest acceptable price of the first buyer, who did not get to trade.

Example:

The highest acceptable prices of the four buyers are

4.00 2.00 0.25 0.00

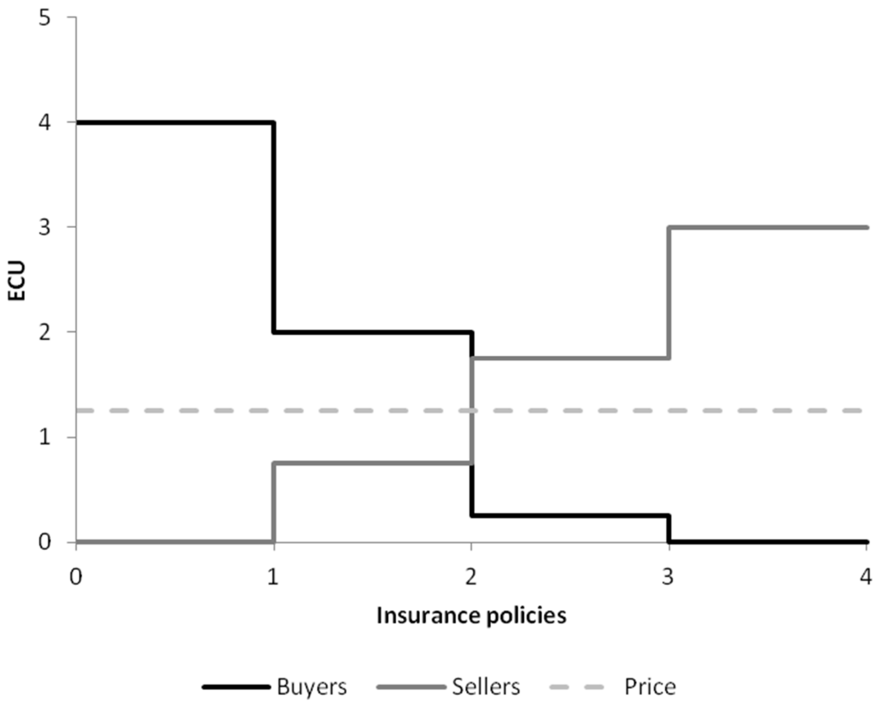
The lowest acceptable prices of the four sellers are

0.00 0.75 1.75 3.00

In this case two insurance policies will be traded: First the pair with 4.00 and 0.00 trades and then the pair with 2.00 and 0.75. In the first buyer-seller-pair that does *not* trade, the buyer has a highest acceptable price of 0.25 and the seller has a lowest acceptable price of 1.75.

The market price is then determined as follows:
(i) The relevant value is 1.75 because 1.75 is lower than 2.00.
(ii) The relevant value is 0.75 because 0.75 is higher than 0.25.
The mean value from (i) and (ii) and therefore the market price is (1.75 + 0.75)/2 = 2.50/2 = 1.25.

The following diagram shows the highest acceptable prices of buyers and the smallest acceptable prices of sellers as well as the resulting price:



If there are multiple buyers entering the same highest acceptable price, it is determined randomly who of them trades first. In the same way, it is randomly determined which seller trades first, if multiple sellers enter the same lowest acceptable price.]

Chapter 2

The role of communication and reputation information in patients' choice of a physician

Reference

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The role of communication and reputation information in patients' choice of a physician*

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October 25, 2022

Abstract

When choosing a new physician, many patients search for credible information about physicians in the internet. As patients usually base their choice on a rich set of information, we study how information about physicians' past behavior (i.e. reputation information) and information that physicians communicate about their intended behavior affect patients' choice. In our theory-guided laboratory experiment, subjects in the role of patients choose one of two subjects in the role of physicians for medical treatment. We observe that patients prefer physicians with lower travel costs, but also value a good reputation and specific message content. The latter is particularly important for patients' choice if no reputation information is available. Overall, our observations reveal that patients profit from the availability of reputation information, while the sole opportunity for physicians to send a message to patients does not affect patient benefit. It seems to be the specific content of messages that matters.

Keywords: physician choice, reputation, communication, laboratory experiment

JEL Codes: I11, C91, D83

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1 Introduction

Patients' choice of a physician is a classical problem of asymmetric information. Given limited knowledge about the quality of physicians' medical treatment, many patients search for credible information about physicians' performance in the internet (Lu & Rui, 2018; Scott et al., 2005). In particular, physician quality measures based on past performance like ratings or report cards have gained more attention among patients in recent years (e.g., Hanauer et al., 2014). For example, Bensnes and Huitfeldt (2021) observe that the demand for physicians in Norway who are rated higher on an online review platform increases compared to lower rated physicians. Studying the choice of 3.4 million patients of family physicians in the English health care market, Santos et al. (2017) also conclude that patients are more likely to choose practices with higher quality measures. Despite highlighting the importance of quality measures, the study by Santos et al. demonstrates that patients' valuations of practices decrease with increasing distance from their home. That travel costs can be a serious restriction in patients' choice of a physician is also indicated in the discrete choice experiment by Lagarde et al. (2015).[1]

While previous research on the determinants of patients' choice of a physician usually focuses on information about physicians' past performance, patients can also access information that physicians communicate regarding their future performance. Practice websites, for example, allow physicians to advertise their skills and facilities and, thus, to promise a certain quality of medical treatment. The rules for doing so differ across countries, though. While physicians' opportunities to communicate are restricted more strongly in Germany (Bundesaerztekammer, 2019; Kock, 2013) and France (French National Medical Council, 2013), national medical associations in the US (American Medical Association, 2016) and UK (British Medical Association, 2018a, 2018b) declare less restrictive rules for physician communication. Previous field and laboratory research on the effect of communication opportunities in markets with asymmetric information demonstrate that communicated information about intended behavior can significantly affect the choice of transaction partners (Brosig-Koch & Heinrich, 2018; Heinrich, 2012). It is an open question whether this observation on seller-buyer relationships translates to patients' choice of a physician.[2]

We contribute to previous research on patients' choice of a physician by studying the role of communicated (non-binding) information regarding physicians' future behavior and information about physicians' past performance for this choice. In particular, we run a controlled and theory-guided laboratory experiment in which we systematically vary the information available to patients as well as patients' travel costs. The results of this experiment allow us to infer the relative importance of these types of information on patients' choice of a physician and on physicians' medical service provision for patients.

[1]Similarly, studies show that patients consider travel costs and quality measures for their choice of hospital (e.g., Avdic et al., 2019; Gutacker et al., 2016; Tay, 2003; Varkevisser et al., 2012; Wübker et al., 2010).

[2]A recent first laboratory experiment on the effect of communication in a physician-patient relationship rather casts some doubt on the transferability of results from other settings to health care provision. While previous behavioral experiments on non-medical settings reveal that cheap-talk communication between players can increase the efficiency and equality of outcomes in bilateral bargaining (e.g., Brosig, 2006; Roth, 1995), Then (2022) observes that, if there are effects, medical service provision is worse when allowing patients to send a message to their physician.

Previous laboratory research in health economics studying the effect of quality information focuses on physician provision behavior and abstracts from patients' active choice of a physician (Godager et al., 2016; Huesmann et al., 2020; Kairies & Krieger, 2013).[3] In experiments on credence good markets, Huck et al. (2016) and Mimra et al. (2016) implement a setting in which customers can (imperfectly) observe experts' previous decisions before choosing an expert. Huck et al. (2016) find that revealing experts' market shares increases customers' willingness to consult. Mimra et al. (2016) observe that under fixed prices customers choose experts based on previous quality and exhibit similar decision patterns under private and public histories. However, both studies do not involve a medical decision-environment and do not focus on the interplay of information about past performance and communicated (non-binding) information about future behavior.

From a game-theoretic point of view, communicating non-binding information is cheap talk and should not influence decisions as long as players' interests are opposed (see Crawford, 1998, for an overview). Laboratory research still reveals a significant behavioral effect of cheap-talk communication in a variety of games. Research on the relative importance of communication and observation is rather scarce, though. One of the few exceptions is the laboratory experiment by Duffy and Feltovich (2002) which involves bilateral games like stag hunt, prisoner's dilemma, and chicken games. They find that one-sided communication about intended play as well as observation of past behavior increase the frequency of cooperation, the frequency of coordination, and the payoffs. The relative importance of communication and observation depends on the specific type of interaction, though. In the stag hunt game, in which players' incentives are more aligned, cheap talk performs relatively better. In chicken and prisoner's dilemma games, observation turns out to be more effective. In line with that, a related experiment on the trust game by Bracht and Feltovich (2009) shows that observation of second movers' previous decisions substantially increases efficiency while communicated intentions have almost no effect. Brosig-Koch and Heinrich (2018) combine laboratory and field data to study the effects of communication content and its interaction with information about past behavior on buyers' choice of a seller. Although buyers' and sellers' interests are opposed, they observe that in both, the laboratory and the field, not only prices, but also information about sellers' past decisions as well as sellers' messages influence the choice of a seller. Their study also reveals that the specific content of messages is decisive. Brosig-Koch and Heinrich (2018) particularly focus on two prominent explanations for the effectiveness of cheap-talk communication that have emerged in the literature. One explanation states that communication reduces players' social distance, thereby making the opponent's payoff more salient (see, e.g., Charness & Gneezy, 2008). The other explanation argues that (non-binding) promises impact behavior because players are guilt averse (Charness & Dufwenberg, 2006) or have a preference for promise keeping *per se* (Vanberg, 2008). The observations made by Brosig-Koch and Heinrich (2018) indicate that both explanations are relevant. If sellers are able to make specific (non-binding) promises about their future behavior, buyers prefer sellers who make such specific promises. If specific promises are infeasible, buyers prefer sellers whose arguments reduce the social distance between transaction partners. These results hold independent of the availability of

[3]Brosig-Koch et al. (2022) analyze physicians' provision of information in the context of patient referrals. Also this study does not focus on patients' active choice of a physician.

information about sellers' past behavior, which is important in any case.[4]

To the best of our knowledge, there is neither a study investigating communication content nor one that tests the relative importance of communication content and its interaction with information about past behavior in patients' choice of a physician. In the following section we present the experimental set-up of our study. Afterwards we introduce the theoretical predictions with regard to both, patients' choice of a physician as well as physicians' medical service provision. Section 4 summarizes our observations and Section 5 concludes.

2 Experiment

2.1 Experimental design

In our experiment, subjects are matched in groups of three with one subject in the role of a patient P facing two subjects in the role of physicians (doctors) D_j with $j \in \{1, 2\}$. The subject in the role of a patient chooses a physician for medical treatment. The chosen subject in the role of a physician D_j selects a treatment quality for this patient q_j.[5] The treatment quality selected by the chosen physician determines the physician's profit $\pi_j(q_j)$. More specifically, each physician D_j is paid a lump sum payment $p = 200$ for every patient treated and faces variable costs $c(q_j) = 0.02q_j^2$ increasing with quality. Their profit is hence specified as $\pi_j(q_j) = 200 - 0.02q_j^2$ for every patient treated. A physician who is not chosen for treatment receives a profit of zero. We require physicians to provide a minimum quality of $q^{min} = 20$. Moreover, physicians may not provide a quality higher than $q^{max} = 100$, which would result in negative profits. Hence, we restrict physician quality to $q_j \in [20, 100]$ $\forall j \in \{1, 2\}$. Patients are assumed to be fully insured and only face travel costs $\tau_j > 0$ to physician D_j. We assume that a patient's travel costs to physician D_j include all monetary and time costs for travelling to this physician and receiving treatment. Patient benefit $b(q_j, \tau_j)$ decreases in travel costs to the chosen physician D_j and increases in treatment quality q_j selected by this physician with decreasing marginal benefits. We particularly set patient benefit to $b(q_j, \tau_j) = 4q_j - 0.02q_j^2 - \tau_j$. In the experiment, travel costs are independently drawn from a uniform distribution on the interval $[20, 60]$. The upper bound of 60 ensures that patient benefits are non-negative for all possible treatment qualities.

We repeat this one-shot interaction over 40 periods. In each period $t \in \{1, .., 40\}$, subjects are newly matched with each other while keeping their role as a patient and a physician, respectively. In each period, the patient's travel costs are newly and independently drawn from a uniform distribution on the interval $[20, 60]$. As such, our repeated one-shot interaction setting resembles a situation of a patient that has to repeatedly choose a new physician.

[4] The observations on the relative importance of promises and social distance are in line with findings by He et al. (2017). In a laboratory experiment on cooperation in a prisoner's dilemma game, they observe that the opportunity to make specific promises is effective, while a decreased social distance (implemented as visual identification of players) does not increase cooperativeness.

[5] Note that we keep the experimental design as simple as possible to cleanly identify the behavioral effects of our experimental parameters. A more general setting might include a group of patients selecting a physician from different subsets of known physicians. From a theoretical point of view, the underlying mechanisms should be equal to our simple setting as selecting a physician in a group can be done by a connection of series of pairwise comparisons.

Table 1: Experimental conditions

	Baseline	**R**	**N-M**	**R-M**
Reputation information	-	average quality and last period's quality	-	average quality and last period's quality
Communicated information	-	-	physician messages	physician messages
Number of subjects	60	60	60	60
Matching groups	5	5	5	5

We implement four experimental conditions that systematically vary with regard to the information that patients receive for their choice in each period. In all four conditions, patients are informed about their travel costs to the two physicians in their group. As physicians usually do not know exactly the distance or travel costs of their potential patients, they are informed that the patient's travel costs are independently drawn from a uniform distribution on the interval $[20, 60]$, but do not receive information about the patient's specific travel costs. In conditions with reputation information, patients receive information about each physician D_j's previous treatment qualities in each period $t \in \{2, ..., 40\}$ except the first period. In particular, they are shown the average treatment quality provided in all previous periods $\overline{q}_{j,t} = \frac{1}{t-1}\sum_{i=1}^{t-1} q_{j,i}$ and the treatment quality provided in the last period $q_{j,t-1}$. As such, our experimental conditions with and without a reputation mechanism resemble extreme cases in which reputation information either provides observation of past behavior or does not exist (similar to the experiments by Bracht & Feltovich, 2009; Duffy & Feltovich, 2002; Huck et al., 2016; Mimra et al., 2016). We assume that physicians know their own treatment qualities, but do not know which other physician the patient considers for their choice. Hence, physicians are shown their own reputation information, but no information about the other physician. In conditions with non-binding communication, physicians can send a text message to the patient. The free-form text messages resemble the possibility to provide additional information on own web pages or online profiles. Table 1 summarizes the experimental conditions.

2.2 Experimental protocol

After arriving at the lab, subjects were randomly assigned to cubicles in which the instructions had been placed before (see Appendix A.1 for the instructions). In order to check whether subjects had understood the decision setting, we implemented a short comprehension test (see Appendix A.2 for the comprehension questions). After all subjects had answered the questions correctly, they learned about their role, which remained fixed in all 40 periods.

In each period, two subjects in the role of physicians were matched with one subject in the role of a patient. We re-matched subjects in each period within groups of 12, consisting of four patients and eight physicians. Re-matching was done with the restriction that subjects would never meet the same two other subjects in two consecutive periods and subjects were informed accordingly. At the beginning of each period, subjects in the role of physicians had to decide on the quality they would provide in case they were chosen for treatment. This allows us to observe treatment choices made by all physicians instead of only those made by the chosen physicians. As such, our design includes features of the so-called strategy method introduced by Selten (1967). Depending on the experimental condition, subjects in the role of physicians were also able to write a message to the patient. Messages were restricted to 420 characters. It was not permitted to mention personal details such as name, age, address, field of study, or profession in order to maintain anonymity between subjects.

After subjects in the role of physicians had made their decisions, subjects in the role of patients were shown information about the two physicians they could choose. Depending on the experimental condition, subjects in the role of patients were informed about physician reputation and physician messages besides travel costs to physicians. For travel costs, we randomly drew eight series of costs before the experiment, one for each physician in a matching group. In order to keep behavioral observations comparable across conditions, we used the same series of costs for all matching groups. After subjects in the role of patients had chosen a physician, subjects in the role of physicians were re-matched to another patient for the next period. They were informed about patients' decisions and their earnings from each period only at the end of the experiment. Similarly, patients were informed about the chosen physicians' treatment qualities and their earnings from each period at the end of the experiment. All amounts were given in Eurocents and subjects were paid the sum of their earnings from all 40 periods.

As a control measurement for subjects' social orientation, we implemented a social value orientation test using the decomposed game technique (Liebrand, 1984; McClintock and Liebrand, 1988; see also Brosig, 2002, for a description) as second part of the experiment. In this test, amounts were given in Euro and subjects were paid the sum of all amounts they allocated to themselves and all amounts another subject allocated to "other" in the 24 questions. Subjects were informed at the beginning of the experiment that there would be a second part. The relevant instructions were however only shown on screen after the 40 periods of the main experiment ended. After the second part of the experiment, we asked subjects to complete a short questionnaire, which contained questions on risk preferences (questions included in the German Socio Economic Panel, see Dohmen et al., 2011), questions related to altruism (based on questions included in the European Values Study, European Values Study, 2015, in the World Values Survey, Inglehart et al., 2014, and in the Global Preference Survey, Falk et al., 2018), and questions on demographics (age, gender, nationality, and field of study).

The experiment was programmed with z-Tree (Fischbacher, 2007) and conducted at the Essen Laboratory for Experimental Economics (elfe) at the University of Duisburg-Essen, Germany. The 14 experimental sessions lasted 90 to 165 minutes and subjects earned 44.51 Euro on average. We used ORSEE (Greiner, 2015) to recruit 240 participants from different fields of study. Gender was balanced so that roughly half of the participants in each matching group were female.

3 Theoretical predictions

In this section, we derive the equilibrium predictions for our finitely repeated one-shot interactions. We denote the physician that patient P chooses in period t with c_t^* and the quality that physician D_j would provide in case they are chosen by P in this period with $q_{j,t}^*$. The patient P is assumed to maximize the sum of expected benefits over the $T = 40$ periods. Each physician D_j is assumed to maximize their sum of expected utilities over the $T = 40$ periods.

As noted before, patient P's benefit in period t is set to

$$b(q_{j,t}, \tau_{j,t}) = 4q_{j,t} - 0.02q_{j,t}^2 - \tau_{j,t}.$$

Accordingly, the expected benefit of patient P in period t equals

$$\mathbb{E}[b(q_{j,t}, \tau_{j,t})] = 4\mathbb{E}[q_{j,t}] - 0.02\mathbb{E}[q_{j,t}^2] - \tau_{j,t}.$$

Similar to earlier models of physician behavior (e.g., Ellis and McGuire, 1986, as well as Ellis and McGuire, 1990), we assume that physicians derive utility from increasing their own profit and the patient's health benefit. The weight α_j the physician D_j attaches to the patient's health benefit is interpreted as physician altruism. Physician utility in period t is thus denoted by

$$U_{j,t}(q_{j,t}) = \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(\pi_{j,t}(q_{j,t}) + \alpha_j(\hat{b}(q_{j,t}))) \tag{3.1}$$

$$= \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(200 - 0.02q_{j,t}^2 + \alpha_j(4q_{j,t} - 0.02q_{j,t}^2))$$

$$= \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(200 + 4\alpha_j q_{j,t} - (0.02 + 0.02\alpha_j)q_{j,t}^2)$$

with $q_{j,t} \in [20, 100]$ and $\alpha_j \geq 0$. The indicatorfunction takes the value one if the condition in brackets is fulfilled, i.e., if physician D_j is chosen for treatment in period t. Otherwise, the indicatorfunction takes the value zero and the product equals zero. Hence, the utility of the physician who is not chosen for treatment equals zero. $\hat{b}(q_{j,t}) = b(q_{j,t}, \tau_j) + \tau_j = 4q_{j,t} - 0.02q_{j,t}^2$ denotes the part of patient benefit that physician D_j can influence. Thus, we assume that physicians gain altruistic utility from a patient only if they treat the patient themselves (see also Byambadalai et al., 2019, who make a similar assumption in their model of physician behavior in markets).

The expected utility of physician D_j in period t equals:

$$E[U_{j,t}(q_{j,t})] = E[\mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(\pi_{j,t}(q_{j,t}) + \alpha_j(\hat{b}(q_{j,t})))]$$

$$\longrightarrow E[U_{j,t}(q_{j,t})] = E[\mathbb{1}_{\{D_j \text{ is chosen in period } t\}}]E[(\pi_{j,t}(q_{j,t}) + \alpha_j(\hat{b}(q_{j,t})))]$$

$$\longrightarrow E[U_{j,t}(q_{j,t})] = P(D_j \text{ is chosen in period } t)(200 + 4\alpha_j q_{j,t} - (0.02 + 0.02\alpha_j)q_{j,t}^2).$$

Please note, that we are able to split the expected benefit of a product into the product of two factors expected benefits from the first to the second equation because both factors are independent of each other. In conditions with reputation information, patient P is shown each physician's average treatment quality provided in all previous periods $\overline{q}_{j,t} = \frac{1}{t-1}\sum_{n=1}^{t-1} q_{j,n}$ and each physician's treatment quality provided in the last period $q_{j,t-1}$. Accordingly, in these conditions the probability of physician D_j for being chosen in period t can depend on choices made in periods $1, .., t-1$, with $t \in \{2, .., T\}$. In conditions without reputation information, this is not the case. Here the probability of physician D_j for being chosen in period t depends on the patient's travel costs τ_j to this physician only.[6] These costs are neither known to physicians nor can they influence them. Remember that, apart from the two specific types of quality information in conditions with reputation information, patients and physicians are not provided feedback about the decisions made in previous periods.

For our theoretical predictions, we consider the symmetric preferences for selfishness (see Section 3.1) and for altruism (see Section 3.2) as benchmarks. In Section 3.3, we relax the assumption of common knowledge about physicians‘ (symmetric) utility functions.

3.1 Pure physician selfishness

We first consider the extreme case in which α_j=0 $\forall j \in \{1, 2\}$. In a finitely repeated game with complete information and common knowledge of rationality and selfishness, both physicians will choose the quality $q^{min} = 20$ in all periods $t \in \{1, ..., T\}$. Patient P will choose the physician with the smaller travel costs in every period or one of both if their travel costs are equal. Let's briefly review the result. In the last period T, physicians' quality decisions do not affect their reputation information (if there is any at all). Therefore, in this period patients base their choice of a physician only on travel costs. As physicians do not know their specific travel costs and the expected travel costs are symmetric for both physicians, physicians can assume to be chosen with a probability of $\frac{1}{2}$. Since physicians have symmetric utility functions, they provide the same qualities for medical treatment. For maximizing physician D_j's short-term expected utility in period T, the first-order condition $\frac{\partial \mathbb{E}[U_{j,T}(q_{j,T})]}{\partial q_{j,T}} \stackrel{!}{=} 0$ and $\alpha_j = 0$ therefore lead to $-0.04q_{j,T} = 0$ which results in $q_{j,T} = 0$. Since the second-order condition results in $\frac{\partial \mathbb{E}[U_{j,T}(q_{j,T})]}{(\partial q_{j,T})^2} = -0.04 < 0$, we know that the extremal point is a maximum of the expected utility function $\mathbb{E}[U_{j,T}(q_{j,T})]$. However, we require physicians to provide at least a quality of $q^{min} = 20$. Since the expected utility function is strictly monotonic decreasing in $q_{j,T}$, physicians will choose the lowest possible quality and $q^*_{j,T} = 20$. By backward induction, the same holds for all previous periods. Without any further assumptions, providing an opportunity to write a non-binding text message should not change this result.

Lemma 3.1. If $\tau_1 < \tau_2$, the following strategy vector is the unique subgame perfect Nash equilibrium of the game: $((20, 20, D_1), .., (20, 20, D_1))$.
If $\tau_1 = \tau_2$, the following strategy vector is a subgame perfect Nash equilibrium $\forall\ c^*_1, .., c^*_T \in \{D_1, D_2\}$: $((20, 20, c^*_1), .., (20, 20, c^*_T))$. Therefore, we have 2^T different subgame perfect Nash equilibria of the game.

[6]Note that in conditions with non-binding communication, physicians can send a text message to the patient. This non-binding information is cheap talk and should not influence decisions in our setting, however (e.g., Crawford, 1998). So we do not specifically refer to these conditions here.

If $\tau_1 > \tau_2$, the following strategy vector is the unique subgame perfect Nash equilibrium of the game: $((20, 20, D_2), .., (20, 20, D_2))$.

You can find the proof in Appendix B.1. Now we are able to state hypothesis H1:

H1: If we assume common knowledge of rationality and selfishness, both physicians will provide the legal minimum quality of $q = 20$ in every period of the game. Patients choose the physician with the smaller travel costs in every period or one of both if the travel costs are equal. This applies to all conditions independent of the provision of reputation information and independent of the physicians' opportunity to write a message.

3.2 Symmetric physician altruism

In a finitely repeated game with complete information, common knowledge of rationality, and symmetric physician altruism ($\alpha_1 = \alpha_2 = \alpha > 0$), both physicians will choose the quality $q^*_{j,t} = \max\{20, \frac{100\alpha}{1+\alpha}\}$ in all periods $t \in \{1, ..., T\}$. Patient P will again choose the physician with the smaller travel costs in every period or one of both if their travel costs are equal. The reasoning is analogous to the case of pure selfishness presented in Section 3.1. Also here physicians' quality decisions do not affect their reputation information in the last period T (if there is such information at all). Therefore, patients base their choice of physician in the last period only on travel costs. As physicians do not know the patient's specific travel costs and the expected travel costs are symmetric for both physicians, physicians can assume to be chosen with a probability of $\frac{1}{2}$. Since physicians have symmetric utility functions, they provide the same qualities for medical treatment. For maximizing physician D_j's short-term expected utility in period T, the first-order condition $\frac{\partial \mathbb{E}[U_{j,T}(q_{j,T})]}{\partial q_{j,T}} \overset{!}{=} 0$ therefore leads to $4\alpha + q_{j,T}(-0.04 - 0.04\alpha) = 0$, which results in $q_{j,T} = \frac{4\alpha}{0.04+0.04\alpha} = \frac{100\alpha}{1+\alpha}$. Since the second-order condition results in $\frac{\partial \mathbb{E}[U_{j,T}(q_{j,T})]}{(\partial q_{j,T})^2} = -0.04(1+\alpha) < 0$, we know that the extremal point is a maximum of the expected utility function. However, we require physicians to provide at least a quality of $q^{min} = 20$. If $\frac{100\alpha}{1+\alpha} \leq 20$, we know that $\alpha \leq \frac{1}{4}$ and the expected utility function is strictly monotonic decreasing in $q_{j,T}$ for $q_{j,T} > 20$. Thus, physicians will provide $q^*_{j,T} = \max\{20, \frac{100\alpha}{1+\alpha}\}$. Again, the same holds for previous periods by backward induction. As before, without any further assumptions, cheap talk messages should not affect behavior.

Lemma 3.2. If $\tau_1 < \tau_2$, the following strategy vector is the unique subgame perfect Nash equilibrium of the game:
$((\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_1), .., (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_1))$.
If $\tau_1 = \tau_2$, the following strategy vector is a subgame perfect Nash equilibrium $\forall\ c^*_1, .., c^*_T \in \{D_1, D_2\}$: $((\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, c^*_1), .., (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, c^*_T))$. Therefore the game has 2^T different subgame perfect Nash equilibria.
If $\tau_1 > \tau_2$, the following strategy vector is the unique subgame perfect Nash equilibrium of the game: $((\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_2), .., (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_2))$.

You can find the proof in Appendix B.2. Now we are able to state hypothesis H2:

H2: If we assume common knowledge of rationality and symmetric physician altruism, both physicians will provide the same quality $q = \max\{20, \frac{100\alpha}{1+\alpha}\}$ in every period of the game. If their altruism parameter is $\alpha \leq \frac{1}{4}$, they will provide the legal minimum quality of $q = 20$ in every period of the game. If it is $\alpha > \frac{1}{4}$, they will both provide $q = \frac{100\alpha}{1+\alpha}$ as treatment quality in every period of the game. Patients choose the physician with the smaller travel costs or one of both if the travel costs are equal in every period. This applies to all conditions independent of the provision of reputation information and independent of the physicians' opportunity to write a message.

Note that **H2** is a generalisation of **H1** as it expands its content from selfish physicians ($\alpha = 0$) to physicians with a variety of possible symmetric degrees of altruism ($\alpha \geq 0$).

3.3 Asymmetric physician altruism

If we relax the assumption of common knowledge about physicians' symmetric altruism parameters (see Sections 3.1 and 3.2), predictions differ between conditions with and without reputation information. In conditions without reputation information, physicians' treatment qualities cannot affect their probability of being chosen in the following periods. With the same reasoning as before, physician D_j will provide the quality $q^*_{j,t} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$ in all periods $t \in \{1, ..., T\}$. Patient P will choose the physician D_j with the lower travel costs in every period or one of both physicians if they have equal travel costs. Without any further assumptions, cheap talk messages should not affect behavior also in this case.

Lemma 3.3. If $\tau_1 < \tau_2$, the following strategy vector is the unique subgame perfect Nash equilibrium of the game:
$((\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1), .., (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1))$.
If $\tau_1 = \tau_2$, the following strategy vector is a subgame perfect Nash equilibrium $\forall\ c^*_1, .., c^*_T \in \{D_1, D_2\}$: $((\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, c^*_1), .., (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, c^*_T))$. Therefore, we have 2^T different subgame perfect Nash equilibria of the game.
If $\tau_1 > \tau_2$, the following strategy vector is the unique subgame perfect Nash equilibrium of the game: $((\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_2), .., (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_2))$.

You can find the proof in Appendix B.3. Now we are able to state hypothesis H3:

H3: If we relax the assumption of common knowledge about physicians' symmetric altruism parameters for conditions without reputation information, physician D_j will provide the quality $q_j = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$ in every period of the game. If D_j's altruism parameter is $\alpha_j \leq \frac{1}{4}$, they will provide the legal minimum quality of $q_j = 20$ in every period of the game. If it is $\alpha_j > \frac{1}{4}$, they will provide $q_j = \frac{100\alpha_j}{1+\alpha_j}$ as treatment quality in every period of the game. Patients choose the physician with the smaller travel costs in every period or one of both if the travel costs are equal. This applies to all conditions without reputation information independent of the physicians' opportunity to write a message.

In conditions with reputation information, several reputation equilibria may emerge in which physician D_j chooses a quality that is higher than $q = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$, at least in the first periods of the repeated game. In particular, patients may try to infer physicians' altruism parameters α_j from their reputation information in period t in order to build well-founded expectations about the quality $q_{j,t}$ provided in period t. Under these circumstances, physicians' reputation information may positively influence the probability of being chosen for treatment and it may be rational for physicians to build a high reputation compared to other physicians, at least in the first periods. Thus, there may be subgame perfect Nash equilibria in which it can be rational to build a high reputation in the first periods. Yet, there may also be equilibria in which it can be rational for physicians to sacrifice their reputation for short-term profits. Note that physician D_j's reputation information contains the average treatment quality $\overline{q}_{j,t}$ provided in all $t-1$ previous periods and the quality $q_{j,t-1}$ provided in the last period $t-1$, with $t \in \{2, ...40\}$. In the following, we identify some central characterictics of subgame perfect Nash equilibria that result in conditions with reputation information assuming asymmetric physician altruism. First, we focus on the strategy vector $(q^*_{1,T}, q^*_{2,T}, c^*_T)$ played in the last period of subgame perfect equilibria. Since we relaxed the assumption of symmetric physician altruism, $P(D_j \text{ gets selected in period } t)$ describes the probability for being chosen in period t from the point of view of physician D_j and not necessarily the real probability. These two different probabilities no longer necessarily coincide.

Lemma 3.4. Be $((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ a subgame perfect Nash equilibrium, with $P(D_j \text{ gets selected in period } T) > 0$ for $D_j \in \{D_1, D_2\}$.
$\longrightarrow$ In period T, physician D_j chooses $q^*_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$.

You can find the proof in Appendix B.4. Now we are able to state hypothesis H4a:

H4a: If we relax the assumption of common knowledge about physicians' symmetric altruism parameters for conditions with reputation information, physicians will provide a quality of $q^*_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$ as long as they expect to be chosen by the patient in period T with a positive probability. Based on the reputation information provided, patient P tries to infer each physician's α_j in order to estimate $q^*_{j,T}$. Given this estimated quality and the travel costs, the patient chooses the physician yielding a higher patient benefit. If both physicians are expected to yield an equal patient benefit, the patient chooses one of them.

Second, we identify a lower bound for the qualities chosen in the subgame perfect Nash equilibrium. It is described by the qualities that both physicians would choose under complete information and common knowledge of rationality and symmetric altruism parameters (see Section 3.2).

Lemma 3.5. Be $((q_{1,1}, q_{2,1}, c_1), .., (q_{1,T}, q_{2,T}, c_T))$ a subgame perfect Nash equilibrium and $P(D_j \text{ gets selected in period } T) > 0, \forall j \in \{1, 2\}$.
$\longrightarrow q_{j,i} \geq \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}\ \forall i \in \{1, .., T\}$ and $\forall j \in \{1, 2\}$

You can find the proof in Appendix B.5. Lemma 3.5 leads to the following hypothesis:

H4b: If we relax the assumption of common knowledge about physicians' symmetric altruism parameters for conditions with reputation information, physicians choose in no period a quality below $\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$. Therefore, for every period the quality physicians provide without reputation information marks a lower bound for the quality they provide with reputation information. Based on the reputation information provided, patient P tries to infer each physician's α_j in order to estimate $q^*_{j,t}$. Given this estimated quality and the travel costs, the patient chooses the physician yielding a higher patient benefit. If both physicians are expected to yield an equal patient benefit, the patient chooses one of them.

Third, we identify the dynamics of the qualities provided by physicians over periods.[7] For this we assume patient P to estimate a physician's quality in the next period as the last period's quality minus the difference between the average and the last period's quality, i.e. $q_{j,t} = q_{j,t-1} - (\overline{q}_{j,t} - q_{j,t-1})$.

Lemma 3.6. Be $((\hat{q}_{1,1}, \hat{q}_{2,1}, c_1), .., (\hat{q}_{1,T}, \hat{q}_{2,T}, c_T))$ a subgame perfect Nash equilibrium.
$\rightarrow q_{j,i} \geq q_{j,k}$, $\forall\ i \leq k$ and $\forall j \in \{1, 2\}$.

You can find the proof in Appendix B.7. Choosing $k = i + 1$ in the last Lemma leads to the following hypothesis:

H4c: If we relax the assumption of common knowledge about physicians' symmetric altruism parameters for conditions with reputation information and further assume patient P to estimate a physician's quality in the next period as the last period's quality minus the difference between the average and the last period's quality, the quality a physician D_j chooses is never increasing over periods, especially not from one period to the next period. The last period therefore contains the minimum quality played. Based on the reputation information provided, patient P tries to infer each physician's α_j in order to estimate $q^*_{j,t}$.[8] Given this estimated quality and the travel costs, the patient chooses the physician yielding a higher patient benefit. If both physicians are expected to yield an equal patient benefit, the patient chooses one of them.

Further, we demonstrate that, if we assume that physicians D_1 and D_2 expect each other to choose the maximum quality in all but the last period and that $\tau_1 \leq \tau_2$, the strategy vector $((100, 100, D_1), .., (100, 100, D_1), (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1))$ is a subgame perfect Nash equilibrium. Here physician D_j starts with choosing the maximum quality $q = 100$ in order to signal a high α_j, $\forall j \in \{1, 2\}$.

Lemma 3.7. We assume that physicians D_1 and D_2 expect each other to choose $q_{1,t} = q_{2,t} = 100\ \forall t \in \{1, .., T-1\}$ and we further require $\tau_1 < \tau_2$.
$\longrightarrow ((100, 100, D_1), .., (100, 100, D_1), (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1))$ is a subgame perfect Nash equilibrium.

[7] See Lemma B.1 in Appendix B.6 for a mathematical criterium to identify a subgame perfect Nash equilibrium in the game.

[8] Physicians choose their short-term optimal quality $q^*_{j,t} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$ revealing their α_j at the latest in the last period. However, as long as patients do not know $q^*_{j,t}$, they can only infer an interval in which α_j is located. Per definition, $\alpha_j = 0$ is the lower bound of the interval. As physicians never play a quality $q_{j,t} < q^*_{j,t}$ (Lemma 3.5), their average treatment quality provided in all previous periods $\overline{q}_{j,t}$ and the treatment quality provided in the last period $q_{j,t-1}$ cannot be lower than the optimal quality. Thus, the lowest treatment quality a physician played in previous periods gives the upper bound for the interval from which α_j comes. Since qualities do not increase during the experiment (Lemma 3.6), the interval for α_j remains the same or becomes smaller from period to period.

You can find the proof in Appendix B.8.[9]

Overall, if we relax the assumption of common knowledge about physicians' symmetric altruism parameters, behavior might differ between conditions with and without reputation information. Without reputation information, physician D_j will provide the quality $q^*_{j,t} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$ in all periods $t \in \{1, ..., T\}$. With reputation information, several subgame perfect Nash equilibria may emerge. We particularly demonstrated that building a good reputation and choosing a quality higher than that provided without reputation information can be a subgame-perfect equilibrium strategy, at least in all but the last period. Given that previous experimental studies observe considerable variation in physicians' degree of altruism (Brosig-Koch et al., 2017; Godager & Wiesen, 2013; Li et al., 2017), the predictions derived in this section seem to be the most relevant ones for our experiment, while the predictions included in Sections 3.1 and 3.2 rather serve as benchmarks. Note that all three models do not imply a behavioral effect of physician messages. Hence, without any further assumptions regarding physicians' and patients' utility functions, physician messages are not predicted to have a behavioral impact.

4 Results

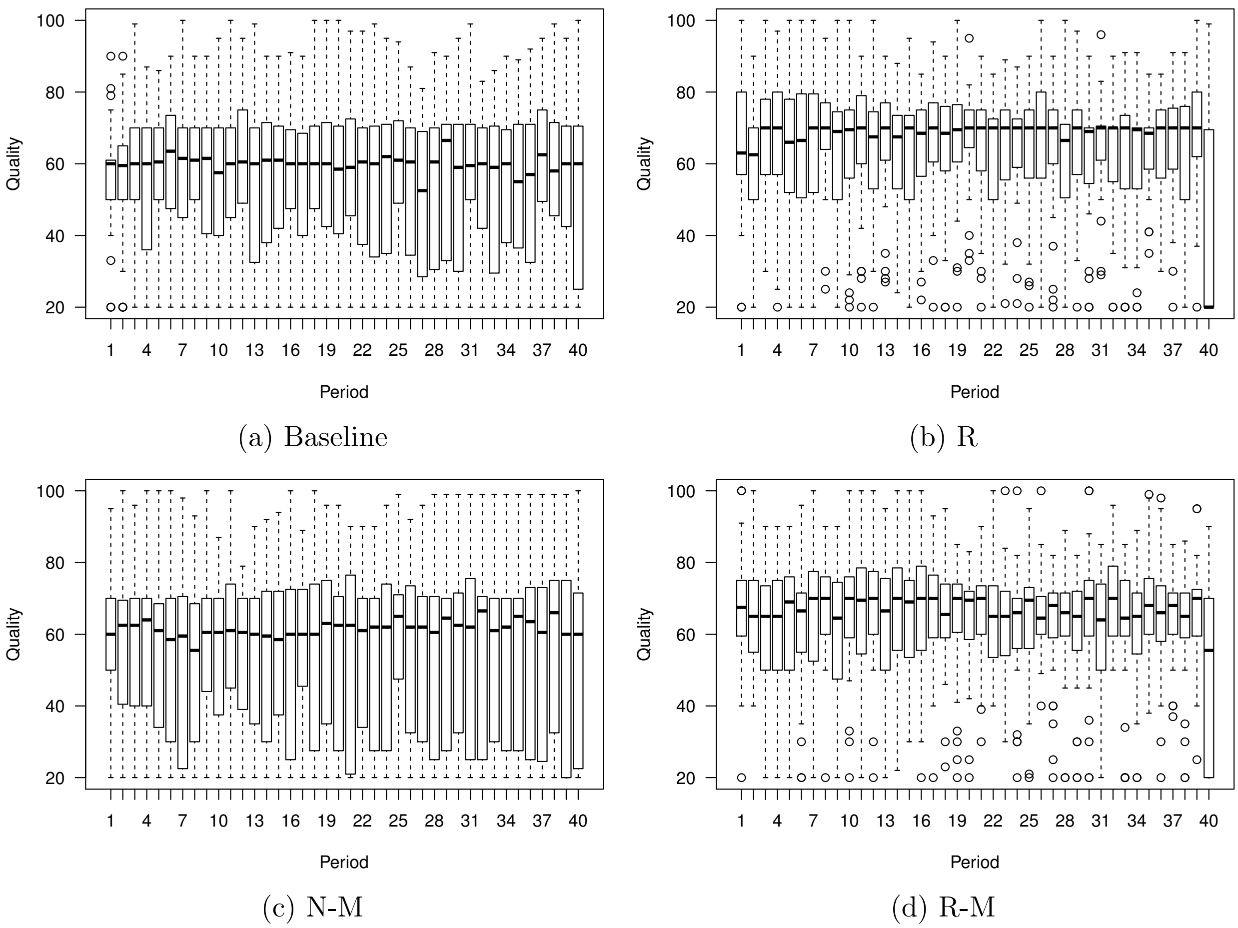
4.1 Physicians' quality provision

In this section, we analyze decision-making of subjects in the role of physicians in our experiment. Figure 1 depicts barplots for the quality provided by subjects in the role of physicians. We observe a higher variance in the conditions without reputation information, Baseline and N-M. Furthermore, the treatment quality drops in the last period in conditions R and R-M.

Table 2 summarizes physicians' quality choices in periods $t \in \{1, ..., 39\}$ and in the last period $T = 40$, respectively. In all conditions, physicians' average treatment qualities in periods $t \in \{1, ..., 39\}$ as well as in $T = 40$ are higher than $q = 25$ and, thus, than the theoretically predicted value for common knowledge of physician selfishness $q^{min} = 20$ (see H1 in Section 3.1; Baseline: $p < 0.001$, R: $p < 0.001$ for $t \in \{1, ..., 39\}$ and $p = 0.030$ for $T = 40$, N-M: $p < 0.001$, R-M: $p < 0.001$, two-sided Wilcoxon signed-rank tests). The finding that treatment qualities are higher than $q = 25$ in period $T = 40$ suggests that, on average, $\alpha > 0$ among subjects. Furthermore, we observe that physicians provide higher treatment qualities in the conditions with reputation information than in conditions without reputation in periods $t \in \{1, ..., 39\}$. Both observations are in line with the assumption of asymmetric physician altruism (see H3, H4a, H4b, and H4c in Section 3.3).

We test the null hypothesis that there are no pairwise differences between conditions with two-sided Mann-Whitney U-tests. The resulting p-values are also given in Table 2. The average qualities are significantly higher in R and in R-M than in Baseline. When we

[9] We identified some further characteristics of the subgame perfect equlibria and included these analyses in Appendix B.9. In Lemma B.2, we prove that physicians can choose any possible quality, still resulting in a subgame perfect Nash equilibrium if physicians estimate their probability to be chosen in the last period to equal zero. In Lemma B.3, we generalize this result to a sequence of periods in which physicians estimate their probability to get selected to equal zero, which could be the case if physicians sacrifice their reputation for short-term profit in an early period of the game.



(a) Baseline (b) R

(c) N-M (d) R-M

Figure 1: Physicians' quality provision over time

pool data over conditions with and without messages, we find a highly significant difference between conditions Baseline/N-M and R/R-M ($p = 0.007$, Mann-Whitney U-test). Nevertheless, in R and R-M subjects' average qualities in periods $t \in \{1, ..., 39\}$ are significantly lower than $q = 95$ and, thus, than the highest possible quality $q^{max} = 100$ (R: $p < 0.001$, R-M: $p < 0.001$, two-sided Wilcoxon signed-rank tests). Apparently, subjects in the role of physicians do not play the strategy described in Lemma 3.7 in Section 3.3. In line with H4c, treatment qualities in the last period are significantly lower than in previous periods in both conditions with reputation information (R: $p = 0.000$, R-M: $p = 0.014$, two-sided Wilcoxon matched-pairs signed-rank tests). However, in the two conditions with reputation information, the treatment quality decreases so strongly that the last period's quality is on average even lower than in conditions without reputation information (Baseline/N-M versus R/R-M: $p = 0.025$, Mann-Whitney U-test). This observation is in contrast to H4a and H4b.

We observe no significant differences in the qualities provided between the conditions with and without physician messages (see Table 2). Thus, in line with our models considered in Section 3 the opportunity to send a message does not affect physicians' quality provision. Nevertheless, the variation of qualities tends to be somewhat larger in conditions with physician messages suggesting that the content of messages might still matter for behavior. We

Table 2: Physicians' treatment quality

	N	Periods $t \in \{1, ..., 39\}$	Period $T = 40$
Baseline	40	55.71	54.12
R	40	64.89	41.25
N-M	40	55.19	53.67
R-M	40	64.52	48.10
Null hypothesis		p-value	
q(Baseline)=q(R)		0.018**	0.021**
q(Baseline)=q(N-M)		0.820	0.921
q(Baseline)=q(R-M)		0.039**	0.298
q(R)=q(R-M)		0.850	0.222

Note: The values for periods $t \in \{1, ..., 39\}$ are calculated using average qualities for subjects in the role of physicians. The reported p-values result from two-sided Mann-Whitney U-tests.
*p <0.1; **p <0.05; ***p <0.01

therefore investigate the influence of message content when analyzing patients' choice of a physician in the next section.

4.2 Patients' choice of physician

Based on our three models included in Section 3, patients' choice of a physician should not be affected by the message the physician sent to the patient. Still, previous research on the selection of transaction partners (Brosig-Koch & Heinrich, 2018) indicates a behavioral influence of the content of such messages. Our analysis of patients' choice of a physician thus follows this research and also considers message content. We particularly focus on two categories of message content which are referred to in prominent explanations of observed communication effects - social proximity (see, e.g., Charness & Gneezy, 2008) and (non-binding) promises (see, e.g., Charness & Dufwenberg, 2006; Vanberg, 2008). Accordingly, we use the following categories to classify message content:

i *Empty:* This category identifies cases in which physicians do not send a message.

ii *Social proximity:* This category identifies messages that indicate a social proximity between physician and patient. Messages are classified accordingly if they are written in an informal style, i.e., if the patient is addressed with the German second-person pronoun "Du" or if they contain an emoticon (chat symbol or smiley).[10]

[10] The second-person pronoun "Du" is included because Kretzenbacher et al. (2006) identify social proximity as the overriding factor in choosing formal or informal pronouns in German. Emoticons are included because they can transmit emotional nonverbal messages in computer-mediated communication (Kasper-Fuehrer & Ashkanasy, 2001; Rivera et al., 1996) and may thus provide further information about the sender (Derks et al., 2008). See also Brosig-Koch and Heinrich (2018), who use the same category in their communication classification.

Table 3: Classification of messages

	N-M	**R-M**	*p*-value
empty	0.149	0.174	0.937
	(-)	(-)	
Content categories			
social proximity	0.266	0.307	0.841
	(0.935)	(0.874)	
promise	0.182	0.187	0.952
	(0.751)	(0.955)	

Note: Share of messages that fall into a category. Krippendorff's Alpha is reported in parentheses. Reported *p*-values result from two-sided Mann-Whitney U-tests based on independent matching groups. They test the null hypothesis that shares in conditions N-M and R-M do not differ.

iii *Promise:* This category identifies messages in which physicians promise to provide a specific treatment quality.

Table 3 summarizes the classification of messages. The category *empty* was coded automatically. The content categories ii and iii were independently coded by two student assistants. They were given a classification scheme, which included explanations and examples for each category. Questions about the classification scheme were discussed in joint meetings before and after the coders trained the classification on a test data set.[11] Subsequently, both student assistants coded the written messages in the experimental data independently. In cases in which the two coders disagree, we use the arithmetic mean of their classification. Note that written text messages can fall into multiple categories or none at all. Table 3 provides the share of messages and Krippendorff's Alpha for the coded categories. Krippendorff's Alpha (Krippendorff, 1980) measures the inter-coder reliability, i.e. the extent to which both coders' classification results coincide, and corrects for agreement by chance. The reliability scores exceed the cutoff value of 0.70 (Krippendorff, 1980). The reported *p*-values are calculated with two-sided Mann-Whitney U-tests and reveal no significant differences between the two conditions with regard to physician messages.

We run separate conditional logistic regressions for each treatment to study how the different kinds of information influence patients' choices. We assume a random utility model in which a patient selects the physician D_j whose treatment quality maximizes expected benefit in period t according to

$$\mathbb{E}[b_{j,t}] = \beta_1 \tau_j + \beta_2 R_{j,t} + \beta_3 M_{j,t} + \epsilon_{j,t}. \tag{4.1}$$

According to the hypotheses derived from our three models, patients are expected to consider their travel costs τ_j to physician D_j in period t. Moreover, assuming asymmetric physician altruism (see Hypotheses 4a, 4b, and 4c), reputation information might matter for patients'

[11] The test data set contains observations from a pilot experiment, which are not included in our analyses.

Table 4: Conditional logistic regressions on patients' choices

	Baseline	R	N-M	R-M
	(1)	(2)	(3)	(4)
travel_costs	-0.114^{***}	-0.074^{***}	-0.096^{***}	-0.082^{***}
	(0.008)	(0.007)	(0.007)	(0.008)
average_quality		0.106^{***}		0.133^{***}
		(0.010)		(0.013)
last_quality		0.003		0.022^{***}
		(0.005)		(0.007)
empty			-0.648^{***}	-0.316
			(0.206)	(0.229)
social_proximity			0.527^{***}	-0.180
			(0.160)	(0.182)
promise			1.042^{***}	0.728^{***}
			(0.201)	(0.202)
Observations	760	760	760	760
McFadden's R^2	0.327	0.337	0.287	0.494

Note: Each observation represents a patient's choice. The dependent variable is an indicator which equals 1 if physician D_j was chosen. We include observations from periods $t \in \{2, ..., 39\}$. Standard errors are reported in parentheses. $^{*}p$ <0.1; $^{**}p$ <0.05; $^{***}p$ <0.01

choice of a physician. We, thus, include the reputation vector $R_{j,t}$, which contains the physician's average treatment quality in previous periods $\overline{q}_{j,t}$ and the quality provided in the last period $q_{j,t-1}$. As described before, the communication vector $M_{j,t}$ contains variables referring to the attributes of physician D_j's message. We include a dummy variable that takes the value 1 if the message is empty and 0 otherwise. Furthermore, we include variables for the content categories *social proximity* and *promise*. Based on the classification by the two coders, these variables can take the values 0, 0.5, and 1. The unobserved error terms $\epsilon_{j,t}$ are assumed to be independently identically distributed with the type 1 extreme value distribution. For the analysis of patients' choice of physician, we only consider periods $t \in \{2, ..., 39\}$ in which reputation information may influence physicians' as well as patients' decisions in conditions R and R-M. Table 4 shows the results.

The regression analysis reveals a negative impact of travel costs on a physician's probability of being chosen in all conditions. This is in line with our models presented in Section 3. In the conditions with reputation information, R and R-M, patients' choices are significantly influenced by physicians' average treatment qualities provided in previous periods. This observation is in line with the assumption of asymmetric physician altruism. The last period's quality significantly affects patients' choices in condition R-M but not in condition R. Nevertheless, the effect is relatively small compared to that of average treatment quality. With respect to communicated information, we find that a non-binding quality promise significantly increases a physician's chance of being chosen. If reputation information is absent, patients are also more likely to choose physicians who send a written message and physicians who use their message to increase social proximity to patients. The observed effects of communication including non-empty messages, messages increasing social proximity, and messages with non-binding promises are not predicted by our models included in Section 3.

As a robustness check, we run the conditional logistic regressions also including the last period $T = 40$ and separately for periods $t \in \{2, ..., 20\}$ and periods $t \in \{21, ..., 39\}$. The results reported in Appendix C show qualitatively the same influences on patients' choices as for periods $t \in \{2, ..., 39\}$ (see Tables C.1, C.2, and C.3).

Based on the conditional logistic regressions for periods $t \in \{2, ..., 39\}$, we estimate patients' willingness to invest travel costs for reputation information and the information communicated in physician messages. Figure 2 depicts the results. We find that patients are willing to invest 14.29 Eurocents more in condition R and 16.21 Eurocents more in R-M if the physician has provided 10 additional percentage points of average treatment quality in previous periods (R: $p = 0.000$, R-M: $p = 0.000$, 1000 bootstrap replications). However, patients do only accept 2.65 Eurocents higher travel costs for 10 additional units of quality in the last period in condition R-M ($p = 0.002$) but not in R ($p = 0.652$). Although both kinds of reputation information are strongly correlated across the conditions with reputation (Spearman's $\rho = 0.671$, $p < 0.001$), patients value average quality more.

Regarding information which physicians communicated, patients spend 10.85 Eurocents higher travel costs in N-M and 8.87 Eurocents more in R-M if physicians make a quality promise in their messages (N-M: $p = 0.000$, R-M: $p = 0.000$). When reputation information is absent, they are willing to accept 5.49 Eurocents higher travel costs if physicians send a message that increases social proximity ($p = 0.002$). Empty messages decrease patients' willingness to invest travel costs by 6.75 Eurocents ($p = 0.002$) in N-M.

4.3 Patient benefits

In this section, we focus on the outcomes of patients' choices, i.e. patients' benefits. By investigating these benefits we can say something about the quality of patients' choices. As for patients' choice of physician, we first look at observations in periods $t \in \{2, ..., 39\}$. Figure 3 shows boxplots for the patient benefits resulting from subjects' decisions in each of the four experimental conditions. The average values, which are clustered by independent observations, i.e. the matching groups, are provided in Table 5. We use two-sided Mann-Whitney U-tests to analyze if there are pairwise differences between conditions. In line with physicians' treatment qualities, we find that patient benefits are significantly higher in periods $t \in \{2, ..., 39\}$ in conditions with reputation information than in conditions without reputation (Baseline vs. R: $p = 0.016$, Baseline vs. R-M: $p = 0.008$, N-M vs. R: $p = 0.008$, N-M vs. R-M: $p = 0.008$). Also in line with the decreasing treatment quality, patient benefits decrease significantly in the last period in conditions with reputation (R: $p = 0.063$, R-M: $p = 0.063$, two-sided Wilcoxon matched-paires signed-rank tests) while patient benefits in the conditions without reputation remain relatively stable (Baseline: $p = 0.438$, N-M: $p = 0.313$). In contrast to previous periods, there are no pairwise differences in patient benefits in the last period between conditions (Baseline vs. R: $p = 0.222$, Baseline vs. N-M: $p = 0.841$, Baseline vs. R-M: $p = 1.000$, R vs. R-M: $p = 0.421$, N-M vs. R-M: $p = 0.690$). As there are no significant differences between conditions with and without physician messages ($p > 0.222$), there seems to be no influence on benefits from physicians' sole opportunity

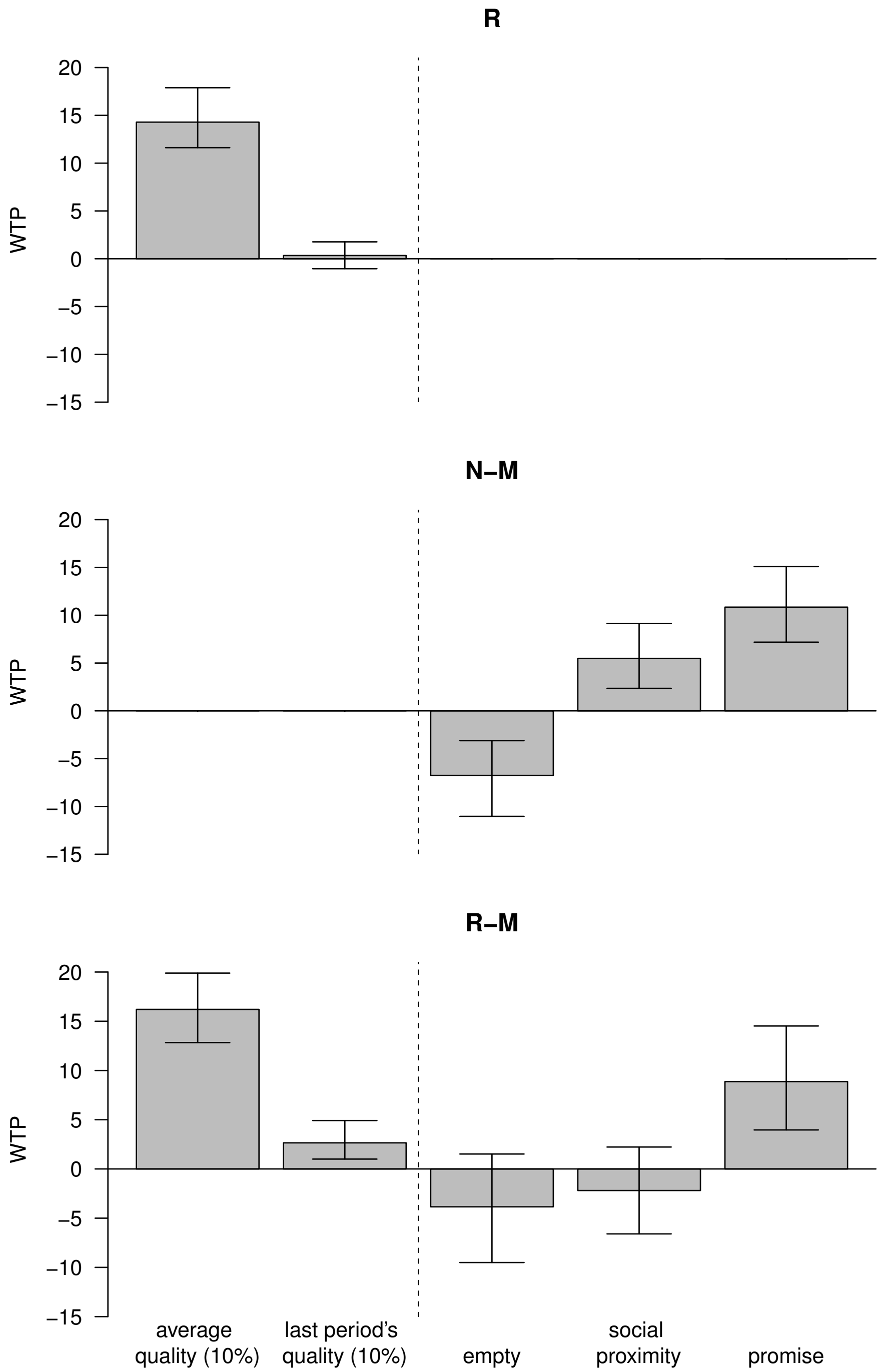


Figure 2: Patients' willingness to invest travel costs for information (95 percent bootstrapped confidence intervals)

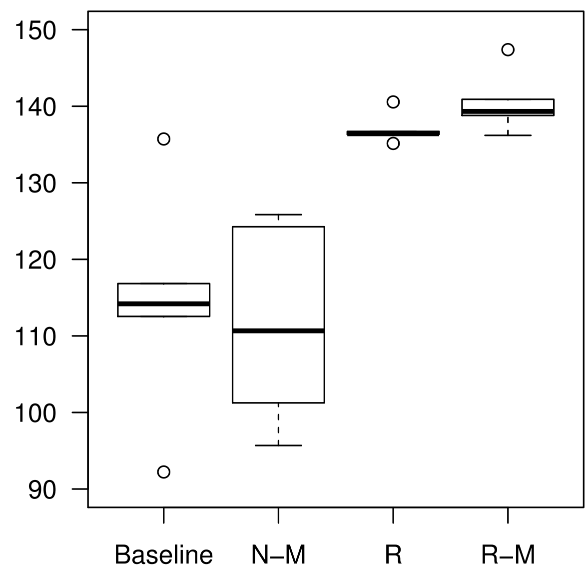


Figure 3: Patient benefits

to send a message. These findings regarding reputation information and physician messages are also confirmed by mixed-model regressions in which we control for physicians' personal characteristics (see Table C.4 in Appendix C for the results). However, in these regressions, we also observe that the content of physician messages matters. In particular, we find a positive effect of non-binding quality promises on patient benefits in condition N-M.

Table 5 also contains two benchmarks for patient benefits in order to evaluate the quality of patients' choices. First, we include benefits that would have been realized in expectation if patients had chosen randomly. Second, we include the benefits that would have been realized if patients could have identified the physician with the higher likelihood for a higher benefit. That is, if patients would have applied a correct expectations rule, which assigns correct weights to available information about physicians. We estimate these weights separately for periods $t \in \{2, ..., 39\}$ and for period $T = 40$ from our data with conditional logistic regressions using the same equations as for patients' choices for which the results are presented in Table 4. However, the dependent variable is now a dummy variable which indicates the physician providing the higher benefit in each choice situation. We compare these two benchmarks to the actual benefits using two-sided Wilcoxon matched-pairs signed-rank tests applied to average values for matching groups for each condition.

As expected, actual patient benefits are significantly higher than with random choice in the conditions with reputation information (R and R-M) in periods $t \in \{2, ..., 39\}$. Without reputation, only patient benefits in the Baseline condition (in which only the two physicians' travel costs are known to patients) are significantly higher than random benefits. Nevertheless, realized benefits fall short of correct expectation benefits in periods $t \in \{2, ..., 39\}$ in the Baseline condition and in condition R-M. In condition N-M, actual benefits do not significantly differ either from those resulting with random choice or from those resulting from a choice based on correct expectations. This might be due to the large variation of

Table 5: Actual and hypothetical patient benefits

		Baseline	R	N-M	R-M
Periods $t \in \{2, ..., 39\}$					
actual	Mean	114.305	137.032	111.541	140.523
random	Mean	111.421	129.613	109.426	129.877
	(p-value)	(0.063)	(0.063)	(0.188)	(0.063)
correct expectations	Mean	117.244	139.310	121.325	142.604
	(p-value)	(0.063)	(0.188)	(0.125)	(0.063)
Period $T = 40$					
actual	Mean	105.347	86.583	96.886	101.868
random	Mean	104.786	75.357	102.619	92.686
	(p-value)	(1.000)	(0.313)	(0.625)	(0.125)
correct expectations	Mean	105.381	85.132	130.241	114.103
	(p-value)	(0.625)	(1.000)	(0.125)	(0.438)

Note: Mean actual, random, and correct expectations patient benefits in periods $t \in \{2, ..., 39\}$ and in period $T = 40$. P-values from two-sided Wilcoxon matched-paires signed-rank tests are provided in parentheses. They test the null hypothesis that the average matching group benefits equal the hypothetical benefits ($N = 5$).

benefits in this condition. A large variation of benefits can also be observed in the last period of all conditions. Accordingly, we no longer observe a significant difference between actual patient benefits and the two benchmarks in all four conditions in this period.

We further investigate how patients' actual willingness to invest travel costs for information differs from the one under the correct expectations rule. For this purpose, we calculate the difference between the patients' willingness to invest travel costs resulting from estimates of the correct expectations rule and their observed willingness to invest travel costs for all kinds of information available (see Section 4.2). The differences are illustrated in Figure C.1 in Appendix C.

In the conditions with reputation information, patients should accept higher travel costs for 10 additional percentage points of average treatment quality in previous periods (R: $\Delta = 9.31$, $p = 0.000$; R-M: $\Delta = 11.76$, $p = 0.000$, 1000 bootstrap replications). Regarding the information that physicians communicated, the valuation of promises should depend more on the availability of reputation information. If patients do not receive reputation information (N-M), they should invest less travel costs for physicians promising a treatment quality than for physicians sending no such promise instead of more ($\Delta = -27.39$, $p = 0.000$). If reputation information is available (R-M), patients should accept higher travel costs for promises ($\Delta = 4.60$, $p = 0.022$). Furthermore, patients could rely more on reputation information and accept higher travel costs for physicians sending no message in condition

R-M ($\Delta = 6.48$, $p = 0.006$).

5 Conclusion

We conducted a controlled laboratory experiment to study patients' choice of a physician. Our focus was particularly on the relative importance of physicians' communicated information about their intended behavior and its interaction with information about physicians' past behavior in this choice. Overall, our results reveal that physicians provide higher treatment qualities if patients can base their choice on physicians' past behavior. This observation is in line with a model assuming asymmetric physician altruism. As we theoretically show, neither common knowledge of pure physician selfishness, nor common knowledge of symmetric physician altruism would lead to such a behavior.

As a result, patients profit from an environment in which they can access information about physicians' past behavior. Providing the sole opportunity for physicians to send non-binding messages to their patients has no such effect, however. It is the content of messages that matters for patients' choice of a physician. In particular, focusing on this choice, our data reveal that patients do not just prefer physicians with lower travel costs, but that they also value a good reputation and specific message content. If reputation information is available, patients prefer physicians with a higher average of previous treatment qualities as well as physicians who make a non-binding promise of specific quality. If there is no access to reputation information, patients generally prefer physicians who send a text message but still value the content of the message. In particular, without reputation information patients do not only prefer physicians who make a quality promise but they are also more likely to choose physicians whose arguments reduce social distance. This indicates that arguments reducing social distance have a more prominent role in the choice of a physician compared to the choice of sellers in markets (Brosig-Koch & Heinrich, 2018) or to cooperation in social dilemmas (He et al., 2017) as it matters here even when specific quality promises are feasible.

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Appendices

A Further information on the experiment

A.1 Instructions of the experiment (translated from German)

Note that the instructions relate to the Baseline condition. Changes for other conditions are given in squared brackets [].

Welcome to the experiment!

You are participating in a study on decision-making in experimental economics research. During the experiment, you are asked to make decisions. By doing so, you can earn money. How much money that is depends on your decisions and on the decisions of other participants.

Immediately after the experiment, all participants are paid individually in cash. Please stay therefore seated after the experiment until your cubicle number is called.

All amounts of money are given in Euro during the experiment.

The experiment takes about 180 minutes and consists of two different parts. Before each of the two parts of the experiment, you receive detailed instructions. All participants receive exactly the same instructions.

Please note that neither your decisions in the first part of the experiment nor your decisions in the second part of the experiment have any influence on the other part of the experiment.

During the experiment, you receive no information about the identity of other participants. Likewise, other participants receive no information about your identity.

For simplicity reasons, the masculine form is used representative of all genders in the instructions.

Instructions for part 1

Please read the following instructions carefully. In case you have questions, you can raise your hand or open the door at any time. We will then come to your cubicle and answer your question.

In the first part of the experiment, you are taking part in 40 decision periods. There are participants in the role of patients and participants in the role of physicians.

Description of the decision periods

In each of the 40 decision periods, one patient interacts with two physicians. The patient chooses one of the two physicians for medical treatment and is subsequently treated by the chosen physician.

You get to know at the beginning of the first decision period if you decide in the role of a patient or in the role of a physician in the 40 periods. You keep your role, patient or physician, during all 40 decision periods. The other two participants are randomly reassigned to you in each of the 40 periods, so that there is always one patient and two physicians interacting with each other. It is ensured that you do not encounter the same group of participants in two consecutive periods.

Patients

The patient needs medical treatment and chooses of the two physicians in his group for treatment. The treatment yields a benefit for the patient. The monetary value of patient benefit is paid out to participants in the role of patients (see section "Payment").

Which factors determine the benefit of a patient?

- The treatment quality provided by the chosen physician (see section "physicians").
- The travel costs: The travel costs incur while choosing a physician. They were drawn randomly and independently from each other for both physicians from the range of 20 to 60 Eurocents. All amounts from this range could be realized with the same probability.

The following information is shown to the patient on screen:

- [*R:* Information about the previous treatment qualities of both physicians (from the second period on): The information contains the quality from the previous period as well as the average quality of all previous periods. The information about a physician is updated in each period based on all of his previous quality decisions.]
- [*M:* The messages of both physicians: Both physicians have the possibility to send a message to the patient at the beginning of each decision period.]
- The travel costs for both physicians.

Physicians

Participants in the role of physicians determine their treatment quality in each period in case they are chosen for treatment by the patient. The quality can be between 20 and 100. The higher the quality provided by a physician the higher are his costs and the lower is his profit. The patient benefit increases with treatment quality. The exact values for all possible treatment qualities are given in Table A.1.

[*M:* physicians have the possibility to send a message to the patient at the beginning of each period. The content of the messages is principally up to physicians. However, it is not permitted to give personal details such as name, age, address, field of study, profession. A participant who breaks these rules may be excluded from the experiment and will not receive any payment. Each message can contain 420 characters at most (about 2.5 lines).]

Which factors determine the profit of a physician?

- The profit of the chosen physicians is determined by the treatment quality. The exact values for all possible treatment qualities are given in Table A.1.
- The profit of the physicians who is not chosen for treatment by the patient is 0 Eurocent.

The following information is shown to physicians on screen:

- Their previous treatment quality (from the second period on): Each physician is shown his actual quality from the previous period as well as his average quality of all previous periods. The values are updated in each period based on all previous quality decisions of the physician.

Payment

The income of each period is determined according to the decisions made:
Period income Patient = Patient benefit as per Table A.1 minus travel costs to the chosen physician
Period income of the chosen physician = Profit of the chosen physician as per Table A.1
Period income of the physician who is not chosen = 0

After the end of part 2 of the experiment, the sum of your period incomes from the 40 decision periods is paid to you in cash together with your earnings from part 2.

Note that no participant will receive any information about his period incomes or about the decisions and period incomes of other participants during the first part of the experiment.

Before we start the 40 decision periods, we ask you to complete a short comprehension test on screen. The decision periods will start as soon as all participants have answered the comprehension questions correctly. These questions do not affect your payment.

Instructions for part 2

The instructions for part 2 of the experiment are shown on screen as soon as the part starts. In part 2 of the experiment, all amounts are given in Euro. At the end of the experiment, your earnings from part 2 are added together with your earnings from part 1 and paid to you in cash.

After part 2 of the experiment, a questionnaire opens. The payment procedure starts after all participants have answered the questionnaire completely.

[*on screen:*

In part 2 of the experiment, you are randomly matched with another participant. In the following we name the other participant "the other person". You do not receive any information about the other person's identity. Conversely, the other person receives no information about your identity.

You and the other person see 24 questions. In each question, you can both choose independently between option A and option B. Each option allocates a certain amount of money in Euro to you and the other person. Your payment is determined by the sum of monetary amounts assigned to you in all 24 questions. You receive the sum of monetary amounts you have allocated to yourself. In addition, you receive the sum of monetary amounts the other person has allocated to you. The other person receives the sum of monetary amounts you allocated to the other person and the sum of monetary amounts they allocated to themselves. This means that your decisions affect both your own payment and the payment of the other person. Likewise, the other person's decisions affect your payment and the payment the other person receives.

For each of the 24 questions, please indicate the option you prefer most. Once you have made your decision, mark the appropriate item and click "OK" to proceed to the next question.]

A.2 Comprehension questions

Please enter an integer between 20 and 100: [x_1]

Please enter an integer between 20 and 60: [x_2]

You have just entered the integers x_1 and x_2.

Assuming, a physician has determined a treatment quality of x_1 and the patient's travel costs for this physician are x_2 Eurocent.

i What would be the period income of the patient if the patient chooses this physician? (in Eurocent)

ii What would be the period income of the physician if the patient chooses this physician? (in Eurocent)

iii What would be the period income of the physician if the patient does not choose this physician? (in Eurocent)

Please mark the correct answer:

The period income from how many decision periods of part 1 is paid out?

a The period income from one randomly selected period.

b The sum of period incomes from three randomly selected periods.

c The sum of period incomes from all periods.

[*R:* Which information about physicians' threatment qualities is shown to patients?

a The treatment quality of this period and the average of all previous periods.

b The treatment quality of the previous period and the average of all previous periods.

c The treatment quality of the previous period and the average of all 40 periods.]

Table A.1: Patient benefit and physician profit in Eurocent

Quality	Patient benefit from treatment (Eurocent)	Profit of the chosen physician (Eurocent)	Quality	Patient benefit from treatment (Eurocent)	Profit of the chosen physician (Eurocent)
20	72.00	192.00	61	169.58	125.58
21	75.18	191.18	62	171.12	123.12
22	78.32	190.32	63	172.62	120.62
23	81.42	189.42	64	174.08	118.08
24	84.48	188.48	65	175.50	115.50
25	87.50	187.50	66	176.88	112.88
26	90.48	186.48	67	178.22	110.22
27	93.42	185.42	68	179.52	107.52
28	96.32	184.32	69	180.78	104.78
29	99.18	183.18	70	182.00	102.00
30	102.00	182.00	71	183.18	99.18
31	104.78	180.78	72	184.32	96.32
32	107.52	179.52	73	185.42	93.42
33	110.22	178.22	74	186.48	90.48
34	112.88	176.88	75	187.50	87.50
35	115.50	175.50	76	188.48	84.48
36	118.08	174.08	77	189.42	81.42
37	120.62	172.62	78	190.32	78.32
38	123.12	171.12	79	191.18	75.18
39	125.58	169.58	80	192.00	72.00
40	128.00	168.00	81	192.78	68.78
41	130.38	166.38	82	193.52	65.52
42	132.72	164.72	83	194.22	62.22
43	135.02	163.02	84	194.88	58.88
44	137.28	161.28	85	195.50	55.50
45	139.50	159.50	86	196.08	52.08
46	141.68	157.68	87	196.62	48.62
47	143.82	155.82	88	197.12	45.12
48	145.92	153.92	89	197.58	41.58
49	147.98	151.98	90	198.00	38.00
50	150.00	150.00	91	198.38	34.38
51	151.98	147.98	92	198.72	30.72
52	153.92	145.92	93	199.02	27.02
53	155.82	143.82	94	199.28	23.28
54	157.68	141.68	95	199.50	19.50
55	159.50	139.50	96	199.68	15.68
56	161.28	137.28	97	199.82	11.82
57	163.02	135.02	98	199.92	7.92
58	164.72	132.72	99	199.98	3.98
59	166.38	130.38	100	200.00	0.00
60	168.00	128.00			

B Additional formal descriptions of Section 3

B.1 Proof of Lemma 3.1

Proof of Lemma 3.1. We start by proving, that if $\tau_1 < \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_1)$ is a unique Nash equilibrium in period T.

(Existence) We assume physician D_1 to provide $q_{1,T} + \epsilon$ in period T with $\epsilon \in (0, 80]$. The higher treatment quality does not affect the physician's probability of being chosen for treatment in period T. Furthermore, providing a higher quality than $q^*_{1,T}$ reduces expected utility $\mathbb{E}(U_1(q_{1,T}))$, which is strictly monotonic decreasing in $q_{1,T}$. As providing a smaller quality than $q^*_{1,T}$ is not allowed, physician D_1 has no incentive to deviate from $q^*_{1,T}$. Due to symmetry, this also holds for physician D_2. As we assumed travel costs to physician D_1 being smaller, i.e. $\tau_1 < \tau_2$, patient P has no incentive to change their choice of a physician either because the patient's benefit function decreases in travel costs and they expect both physicians to provide $q_{1,T} = q_{2,T} = 20$ in period T. Thus, the strategy vector $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_1)$ is a Nash equilibrium in period T. Since physician D_j's expected utility function is strictly monotonic decreasing in quality $q_{j,T}$ and patient P's expected benefit function is strictly decreasing in travel costs τ_j, the Nash equilibrium is strict. Analogously, if $\tau_1 > \tau_2$, we have a strict Nash equilibrium in $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_2)$ in period T. If $\tau_1 = \tau_2$, we have two Nash equilibria $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_1)$ and $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_2)$, because both physicians provide the same expected benefit for patient P.

(Uniqueness) First, we check for another symmetric Nash equilibrium and second, we check for an asymmetric Nash equilibrium. Assuming there exists another Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T) = (q^*_{j,T} + \epsilon, q^*_{j,T} + \epsilon, c_T)$ in period T in which both physicians choose their qualities symmetrically. Again, deviating from the chosen quality does not affect the physician's probability of being chosen for treatment in period T because reputation is irrelevant. Then, physician D_1 can increase their expected utility, which is strictly monotonic decreasing in $q_{j,T}$ by choosing $q^*_{j,t} = 20$. For symmetry reasons, this also holds for physician D_2. Assuming there exists another Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T)$ in period T with $\hat{q}_{1,T} \neq \hat{q}_{2,T}$ in which both physicians choose their qualities asymmetrically. This means that at least one physician D_j does not provide $q^*_{j,T} = 20$. This physician has again an incentive to deviate from this strategy and provide $q^*_{j,T} = 20$. Such a deviation would again not affect the probability of being chosen for treatment but increase expected utility. Further, there is no Nash equilibrium $(q^*_{1,T}, q^*_{2,T}, \hat{c}_T) \neq (q^*_{1,T}, q^*_{2,T}, c^*_T)$ in period T with $\hat{c}_T \neq c^*_T$ because patient P then could increase expected benefit by choosing c^*_T to lower travel costs. Consequently, if we assume $\tau_1 < \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_1)$ is a unique Nash equilibrium in period T. If we instead assume $\tau_1 > \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_2)$ is a unique Nash equilibrium in period T. And if we instead assume $\tau_1 = \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_1)$ and $(q_{1,T}, q_{2,T}, c_T) = (20, 20, D_2)$ are Nash equilibria in period T.

Now we will prove that, if $\tau_1 \neq \tau_2$, the unique Nash equilibrium in period T is also a unique Nash equilibrium in all previous periods and that, if $\tau_1 = \tau_2$, the Nash equilibrium in period T is also a Nash equilibrium in all previous periods. Building reputation for the next period is not rational for physicians because patients will ignore reputation information in period T. Therefore physicians will choose $(q_{1,T-1}, q_{2,T-1}) = (20, 20)$ in the penultimate period as well because it maximizes expected utility in period $T - 1$. By backward induction, physicians will provide $(q_{1,t}, q_{2,t}) = (20, 20)\ \forall\ t \in \{1, .., T\}$ and patients maximize their expected benefit by choosing the physician with the lowest travel costs $D_{\arg\min\{\tau_1,\tau_2\}}$ in all previous periods as well. As a patient's expected benefit is decreasing in travel costs, there is a strict maximum and no incentive to deviate from this strategy. If the travel costs of both physicians are equal, meaning $\tau_1 = \tau_2$, patient P can again choose any of them.

Physician D_j's expected utility in period t equals $\mathbb{E}[U_{j,t}(20)] = \frac{1}{2} * 192 = 96$, physician utility in period t equals $U_{j,t}(20) = \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(192)$, and patient P's benefit from choosing physician D_j equals $b(20, \tau_j) = 72 - \tau_j, \forall t \in \{1, .., T\}$. Therefore, $\sum_{t=1}^{T} \mathbb{E}[U_{j,t}(20)] = \sum_{t=1}^{T} 96 = 96T$ is physician D_j's expected utility over the entire game and $\sum_{t=1}^{T} U_{j,t}(20) = \sum_{t=1}^{T} \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(192)$ their utility. $\sum_{t=1}^{T} 72 - \min\{\tau_1, \tau_2\} = 72T - \min\{\tau_1, \tau_2\}T$ is patient P's benefit over the entire game.

Having a (unique) Nash equilibrium in every period of the game induces the unique subgame perfect Nash equilibrium, as described.

□

B.2 Proof of Lemma 3.2

Proof of Lemma 3.2. The proof is analogue to the proof of Lemma 3.1 (see Appendix B.1). We start by proving, that if $\tau_1 < \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_1)$ is a unique Nash equilibrium in period T.

(Existence) We assume physician D_1 to provide $q_{1,T} + \epsilon$ in period T with $\epsilon \in (0, 100 - \max\{20, \frac{100\alpha}{1+\alpha}\}]$. The higher treatment quality does not affect the physician's probability of being chosen for treatment in period T. Therefore, providing a higher quality than $q^*_{j,T}$ reduces expected utility, which is strictly monotonic decreasing in $q_{j,T}$ for $q_{j,T} > \frac{100\alpha}{1+\alpha}$. Moreover, providing a smaller quality than $q^*_{j,T}$ reduces expected utility, which is strictly monotonic increasing in $q_{j,T}$ for $q_{j,T} < \frac{100\alpha}{1+\alpha}$ or is not allowed because it is below the minimum quality. Hence, physician D_1 has no incentive to deviate from $q^*_{j,T}$ or is not allowed to. Due to symmetry, this also holds for physician D_2. Patient P also does not change their strategy because expected patient benefit is strictly decreasing in travel costs. Thus, if $\tau_1 < \tau_2$, the strategy vector $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_1)$ is a Nash equilibrium in period T.

(Uniqueness) First, we check for another symmetric Nash equilibrium and second, we check for an asymmetric Nash equilibrium. Assuming there exists a Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T) = (q^*_{j,T} + \epsilon, q^*_{j,T} + \epsilon, c_T)$ in which both physicians choose their qualities symmetrically. Again, deviating from the chosen quality does not affect the physician's probability of being chosen for treatment in period T because future reputation is irrelevant. Then, physician D_1 can increase their expected utility, which is strictly monotonic decreasing in $q_{j,T}$ for $q_{j,T} > \frac{100\alpha}{1+\alpha}$ by choosing $q^*_{j,T} = \max\{20, \frac{100\alpha}{1+\alpha}\}$. For symmetry reasons, this also holds for physician D_2. Assuming there exists a Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T) = (q^*_{j,T} - \epsilon, q^*_{j,T} - \epsilon, c_T)$ with $\epsilon \in (0, \max\{20, \frac{100\alpha}{1+\alpha}\} - 20]$ in period T. Again, deviating from this quality does not affect the physician's probability of being chosen for treatment in period T because reputation is irrelevant. Then, physician D_1 can increase expected utility, which is strictly monotonic increasing in $q_{j,T}$ for $q_{j,T} < \frac{100\alpha}{1+\alpha}$ by choosing $q^*_{j,T} = \max\{20, \frac{100\alpha}{1+\alpha}\}$. For symmetry reasons, this also holds for physician D_2. Assuming there exists a Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T)$

with $\hat{q}_{1,T} \neq \hat{q}_{2,T}$ in period T in which both physicians choose their qualities asymmetrically. This means that at least one physician does not provide $q^*_{j,T} = \max\{20, \frac{100\alpha}{1+\alpha}\}$. This physician has again an incentive to deviate from their strategy and to provide $q^*_{j,T} = \max\{20, \frac{100\alpha}{1+\alpha}\}$. Such a deviation would again not affect the probability of being chosen for treatment but increase expected utility. Further, patient P has no incentive to deviate from their choice because expected benefit is strictly decreasing in travel costs. The proof is analogous for $\tau_1 = \tau_2$ and $\tau_1 > \tau_2$.

Consequently, if $\tau_1 < \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_1)$ is a unique Nash equilibrium in period T. If $\tau_1 = \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, c_T)$ is a Nash equilibrium in period T $\forall c_T \in \{D_1, D_2\}$. If $\tau_1 > \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\}, D_2)$ is a unique Nash equilibrium in period T.

Now we will prove that, if $\tau_1 \neq \tau_2$, the unique Nash equilibrium in period T is also a unique Nash equilibrium in all previous periods and that, if $\tau_1 = \tau_2$, the Nash equilibrium in period T is also a Nash equilibrium in all previous periods. Building reputation for the next period is not rational because patients will ignore reputation information in period T. Physicians will choose $(q_{1,T-1}, q_{2,T-1}) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\})$ in the penultimate period as well because it maximizes expected utility in period $T-1$. By backward induction, physicians will provide $(q_{1,t}, q_{2,t}) = (\max\{20, \frac{100\alpha}{1+\alpha}\}, \max\{20, \frac{100\alpha}{1+\alpha}\})$ and patients will choose the physician with the lowest travel costs $\min\{\tau_1, \tau_2\}$ in all previous periods as well.

Physician D_j's expected utility in period t equals $\mathbb{E}[U_{j,t}(\max\{20, \frac{100\alpha}{1+\alpha}\})] = \frac{1}{2}(200 + 4\alpha_j \max\{20, \frac{100\alpha}{1+\alpha}\} - (0.02 + 0.02\alpha_j) \max\{20, \frac{100\alpha}{1+\alpha}\}^2)$, physician utility in period t then equals $\mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(200 + 4\alpha_j \max\{20, \frac{100\alpha}{1+\alpha}\} - (0.02 + 0.02\alpha_j) \max\{20, \frac{100\alpha}{1+\alpha}\}^2)$, and patient P's benefit from choosing physician D_j equals $b(\max\{20, \frac{100\alpha}{1+\alpha}\}, \tau_j) = 4 \max\{20, \frac{100\alpha}{1+\alpha}\} - 0.02 \max\{20, \frac{100\alpha}{1+\alpha}\}^2 - \tau_j$, $\forall t \in \{1, .., T\}$. Therefore, $\sum_{t=1}^{T} \mathbb{E}[U_{j,t}(\max\{20, \frac{100\alpha}{1+\alpha}\})] =$
$\sum_{t=1}^{T} \frac{1}{2}(200 + 4\alpha_j \max\{20, \frac{100\alpha}{1+\alpha}\} - (0.02 + 0.02\alpha_j) \max\{20, \frac{100\alpha}{1+\alpha}\}^2) =$
$\frac{T}{2}(200 + 4\alpha_j \max\{20, \frac{100\alpha}{1+\alpha}\} - (0.02 + 0.02\alpha_j) \max\{20, \frac{100\alpha}{1+\alpha}\}^2)$ is physician D_j's expected utility over the entire game.
$\sum_{t=1}^{T} U_{j,t}(\max\{20, \frac{100\alpha}{1+\alpha}\}) = \sum_{t=1}^{T} \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(200 + 4\alpha_j \max\{20, \frac{100\alpha}{1+\alpha}\} - (0.02 + 0.02\alpha_j) \max\{20, \frac{100\alpha}{1+\alpha}\}^2)$ is their utility over the entire game.
$\sum_{t=1}^{T} b(\max\{20, \frac{100\alpha}{1+\alpha}\}, \tau_j) = \sum_{t=1}^{T} 4 \max\{20, \frac{100\alpha}{1+\alpha}\} - 0.02 \max\{20, \frac{100\alpha}{1+\alpha}\}^2 - \tau_j =$
$4T \max\{20, \frac{100\alpha}{1+\alpha}\} - 0.02T \max\{20, \frac{100\alpha}{1+\alpha}\}^2 - \tau_j T$ is patient P's benefit over the entire game.

Having a (unique) Nash equilibrium in every period of the game induces the unique subgame perfect Nash equilibrium, as described. Having two Nash equilibria per period for T periods, induces 2^T subgame perfect Nash equilibria for $\tau_1 = \tau_2$.

□

B.3 Proof of Lemma 3.3

Proof of Lemma 3.3. The proof is analogous to the proof of Lemma 3.2 (see Appendix B.2). We start by proving, that if $\tau_1 < \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1)$ is a unique Nash equilibrium in period T.

(Existence) We assume physician D_1 to provide $q_{1,T} + \epsilon_1$ in period T with $\epsilon_1 \in (0, 100 - \max\{20, \frac{100\alpha_1}{1+\alpha_1}\}]$. The higher treatment quality does not affect the physician's probability of being chosen for treatment in period T. Therefore, providing a higher quality than $q^*_{j,T}$ reduces $D'_j s$ expected utility, which is strictly monotonic decreasing in $q_{j,T}$ for $q_{j,T} > \frac{100\alpha_j}{1+\alpha_j}$. Moreover, providing a smaller quality than $q^*_{j,T}$ reduces $D'_j s$ expected utility, which is strictly monotonic increasing in $q_{j,T}$ for $q_{j,T} < \frac{100\alpha_j}{1+\alpha_j}$ or is not allowed because it is below the minimum quality. Hence, physician D_1 has no incentive to deviate from $q^*_{1,T}$ or is not allowed to. Due to symmetry, physician D_2 has no incentive to deviate from $q^*_{2,T}$ or is not allowed to. Patient P also does not change their strategy because no reputation information about the physicians is available and expected benefit is strictly decreasing in travel costs. Thus, if $\tau_1 < \tau_2$, the strategy vector $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1)$ is a Nash equilibrium in period T.

(Uniqueness) We check for further symmetric and asymmetric Nash equilibria. First, we start with the symmetric equilibria. Assuming there exists a Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T) = (q^*_{1,T} + \epsilon_1, q^*_{2,T} + \epsilon_2, c_T)$ with $\epsilon_j \in (0, 100 - \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}]$, in which both physicians choose their qualities symmetrically. Again, deviating from the chosen quality does not affect the physician's probability of being chosen for treatment in period T. Then, physician D_j, with $\epsilon_j \neq 0$, can increase expected utility, which is strictly monotonic decreasing in $q_{j,T}$ for $q_{j,T} > \frac{100\alpha_j}{1+\alpha_j}$ by choosing $q^*_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$.

Assuming there exists a symmetric Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T) = (q^*_{1,T} - \epsilon_1, q^*_{2,T} - \epsilon_2, c_T)$ with $\epsilon_j \in (0, \max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - 20]$, in period T. Again, deviating from this quality does not affect the physician's probability of being chosen for treatment in period T. Then, physician D_j can increase expected utility, which is strictly monotonic increasing in $q_{j,T}$ for $q_{j,T} < \frac{100\alpha_j}{1+\alpha_j}$ by choosing $q^*_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$.

Assuming there exists an asymmetric Nash equilibrium $(\hat{q}_{1,T}, \hat{q}_{2,T}, c_T)$ with $\hat{q}_{1,T} \neq \hat{q}_{2,T}$ and $(\hat{q}_{1,T}, \hat{q}_{2,T}) \neq (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\})$ in period T in which both physicians choose their qualities asymmetrically. This means that at least physician D_j does not provide $q^*_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$. This physician has again an incentive to deviate from their strategy and to provide $q^*_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$. Such a deviation would again not affect the probability of being chosen for treatment in period T but increase expected utility. Further, patient P has no incentive to deviate from their choice because no reputation information about the physicians' previous quality choices is available and expected benefit is strictly decreasing in travel costs. The proof is analogous for $\tau_1 = \tau_2$ and $\tau_1 > \tau_2$.

Consequently, if $\tau_1 < \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_1)$ is a unique Nash equilibrium in period T. If $\tau_1 = \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, c_T)$ is a Nash equilibrium in period T $\forall c_T \in \{D_1, D_2\}$. If $\tau_1 > \tau_2$, $(q_{1,T}, q_{2,T}, c_T) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_2)$ is a unique Nash equilibrium in period T.

Now we will prove that, if $\tau_1 \neq \tau_2$, the unique Nash equilibrium in period T is also a unique Nash equilibrium in all previous periods and that, if $\tau_1 = \tau_2$, the Nash equilibrium in period T is also a Nash equilibrium in all previous periods. Because of the lack of reputation information, building reputation for the next period is not possible. Physicians will choose $(q_{1,T-1}, q_{2,T-1}) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\})$ in the penultimate period as well because it maximizes expected utility in period $T-1$. By backward induction, physicians will provide $(q_{1,t}, q_{2,t}) = (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\}, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\})$ and patients will choose the physician with the lowest travel costs $\min\{\tau_1, \tau_2\}$ in all previous periods as well.

Physician D_j's expected utility in period t equals $\mathbb{E}[U_{j,t}(\max\{20, \frac{100\alpha_j}{1+\alpha_j}\})] = \frac{1}{2}(200+4\alpha_j \max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - (0.02+0.02\alpha_j)\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2)$, physician utility in period t then equals $\mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(200+4\alpha_j \max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - (0.02+0.02\alpha_j)\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2)$, and patient P's benefit from choosing physician D_j equals $b(\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}, \tau_j) = 4\max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - 0.02\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2 - \tau_j$, $\forall t \in \{1, .., T\}$. Therefore,
$\sum_{t=1}^{T} \mathbb{E}[U_{j,t}(\max\{20, \frac{100\alpha_j}{1+\alpha_j}\})] = \sum_{t=1}^{T} \frac{1}{2}(200+4\alpha_j \max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - (0.02+0.02\alpha_j)\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2)$ $= \frac{T}{2}(200 + 4\alpha_j \max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - (0.02 + 0.02\alpha_j)\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2)$ is physician D_j's expected utility over the entire game.
$\sum_{t=1}^{T} U_{j,t}(\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}) = \sum_{t=1}^{T} \mathbb{1}_{\{D_j \text{ is chosen in period } t\}}(200 + 4\alpha_j \max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - (0.02 + 0.02\alpha_j)\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2)$ is their utility over the entire game.
$\sum_{t=1}^{T} b(\max\{20, \frac{100\alpha}{1+\alpha_j}\}, \tau_j) = \sum_{t=1}^{T} 4\max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - 0.02\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2 - \tau_j = 4T\max\{20, \frac{100\alpha_j}{1+\alpha_j}\} - 0.02T\max\{20, \frac{100\alpha_j}{1+\alpha_j}\}^2 - \tau_j T$ is patient P's benefit over the entire game.

Having a (unique) Nash equilibrium in every period of the game induces the unique subgame perfect Nash equilibrium, as described. Having two Nash equilibria per period for T periods, induces 2^T subgame perfect Nash equilibria for $\tau_1 = \tau_2$. □

B.4 Proof of Lemma 3.4

Proof of Lemma 3.4. Be $((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ a subgame perfect Nash equilibrium and for simplicity we assume that $D_j = D_1$.
$\longrightarrow$ There is no incentive for physician D_j to deviate in period T.
$\longrightarrow \mathbb{E}(U_1(q^*_{1,T}, q^*_{2,T})) \geq \mathbb{E}(U_1(\hat{q}_{1,T}, q^*_{2,T}))\ \forall \hat{q}_{1,T} \in [20, 100]$ with $\hat{q}_{1,T} \neq q^*_{1,T}$
$\longrightarrow P(D_1 \textit{ gets selected in period } T) * (200 + 4\alpha_1 q^*_{1,T} - (0.02 + 0.02\alpha_1) * (q^*_{1,T})^2)$
$\geq P(D_1 \textit{ gets selected in period } T) * (200 + 4\alpha_1 \hat{q}_{1,T} - (0.02 + 0.02\alpha_1) * (\hat{q}_{1,T})^2)$

Now, we divide both sides of the inequality by $P(D_1 \textit{ gets selected in period } T) \neq 0$ (according to assumption).
$\longrightarrow 200 + 4\alpha_1 q^*_{1,T} - (0.02 + 0.02\alpha_1) * (q^*_{1,T})^2 \geq 200 + 4\alpha_1 \hat{q}_{1,T} - (0.02 + 0.02\alpha_1) * (\hat{q}_{1,T})^2$

For Lemma 3.2, we already proved that the only quality $q^*_{1,T} \in [20, 100]$ fulfilling this equation is $q^*_{1,T} = \max\{20, \frac{100\alpha_1}{1+\alpha_1}\}$. □

B.5 Proof of Lemma 3.5

Proof of Lemma 3.5. Since we required $P(D_j \textit{ gets selected in period } T) > 0, \forall j \in \{1, 2\}$, we know according to Lemma 3.4, that $q_{j,T} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}\ \forall j \in \{1, 2\}$.

Let us assume $\exists\ i \in \{1, .., T-1\}$ and $\exists\ j \in \{1, 2\}$ with $q_{j,i} < \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$. Then, physician D_j could increase their expected profit in period i as well as the probability of getting selected in all periods $i+1,..,T$ by playing $q_{j,i} = \max\{20, \frac{100\alpha_j}{1+\alpha_j}\}$. This is a contradiction to $((q_{1,1}, q_{2,1}, c_1), .., (q_{1,T}, q_{2,T}, c_T))$ being a subgame perfect Nash equilibrium. □

B.6 Lemma B.1

Lemma B.1. $((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ is a subgame perfect Nash equilibrium, with $(q^*_{1,t}, q^*_{2,t}, c^*_t) \in [20, 100]^2 \times \{D_1, D_2\}$ $\forall t \in \{1, .., T\}$.
$\longleftrightarrow \forall t \in \{1, .., T\}$ holds:
$\sum_{i=t}^{T} \mathbb{E}(U_{1,i}(q^*_{1,i}, q^*_{2,i})) \geq \sum_{i=t}^{T} \mathbb{E}(U_{1,i}(\hat{q}_{1,i}, q^*_{2,i}))$, with $(\hat{q}_{1,t}, .., \hat{q}_{1,T}) \neq (q^*_{1,t}, .., q^*_{1,T})$,
$\sum_{i=t}^{T} \mathbb{E}(U_{2,i}(q^*_{1,i}, q^*_{2,i})) \geq \sum_{i=t}^{T} \mathbb{E}(U_{2,i}(q^*_{1,i}, \hat{q}_{2,i}))$, with $(\hat{q}_{2,t}, .., \hat{q}_{2,T}) \neq (q^*_{2,t}, .., q^*_{2,T})$
and $c^*_t \geq \hat{c}_{1,t}$, with $c^*_t \neq \hat{c}_{1,t}$.

Proof. $((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ is a subgame perfect Nash equilibrium, with $(q^*_{1,t}, q^*_{2,t}, c_t) \in [20, 100]^2 \times \{D_1, D_2\}$ $\forall t \in \{1, .., T\}$.

Since every decision period is a subgame, we know that:
$\longleftrightarrow (q^*_{1,t}, q^*_{2,t}, c^*_t)$ is a Nash equilibrium in period t, $\forall t \in \{1, .., T\}$
$\longleftrightarrow \forall t \in \{1, .., T\}$ holds:
$\sum_{i=t}^{T} \mathbb{E}(U_{1,i}(q^*_{1,i}, q^*_{2,i})) \geq \sum_{i=t}^{T} \mathbb{E}(U_{1,i}(\hat{q}_{1,i}, q^*_{2,i}))$, with $(\hat{q}_{1,t}, .., \hat{q}_{1,T}) \neq (q^*_{1,t}, .., q^*_{1,T})$,
$\sum_{i=t}^{T} \mathbb{E}(U_{2,i}(q^*_{1,i}, q^*_{2,i})) \geq \sum_{i=t}^{T} \mathbb{E}(U_{2,i}(q^*_{1,i}, \hat{q}_{2,i}))$, with $(\hat{q}_{2,t}, .., \hat{q}_{2,T}) \neq (q^*_{2,t}, .., q^*_{2,T})$
and $c^*_t \geq \hat{c}_{1,t}$, with $c^*_t \neq \hat{c}_{1,t}$. □

B.7 Proof of Lemma 3.6

Proof of Lemma 3.6. Let us assume that $\exists\ i \leq k$ and $j \in \{1, 2\}$ fulfilling $q_{j,i} < q_{j,k}$. If there are multiple pairs of indices with this property, we assume i and k to have the smallest sum $i + k$ among them. We lead this assumption into a contradiction to the requirement that $((\hat{q}_{1,1}, \hat{q}_{2,1}, c_1), .., (\hat{q}_{1,T}, \hat{q}_{2,T}, c_T))$ is a subgame perfect Nash equilibrium by showing that physician D_j has an incentive to deviate from the strategy.

We will show that physician D_j increases their expected utility if they choose the quality $q_{j,k}$ in period i and $q_{j,i}$ in period k. For the periods 1 to i including, the expected utility stays equal because these periods are not affected by the change in qualities. This is true as well for the periods $k+2$ to T because the average quality after the change in qualities is equal for every period from $k+1$ to T and the quality of the last period as well. It results, that at least from period $k+2$ to T the expected quality is not affected by the change in qualities. Patient P's estimate of quality depends on the average quality a physician played over the previous periods. If a physician deviates to the new strategy, the expected quality $q_{j,i+1}$ in period $i+1$ rises by: $q_{j,k} - (\frac{\overline{q}_{j,i}+q_{j,k}}{i+1} - q_{j,k}) - (q_{j,i} - (\frac{\overline{q}_{j,i}+q_{j,i}}{i+1} - q_{j,i}) - q_{j,i})) = 2 * (q_{j,k} - q_{j,i}) + \frac{q_{j,k}-q_{j,i}}{i+1}$.

The expected quality $q_{j,i+2}$ in period $i+2$ rises by:
$q_{j,i+1} - (\frac{\overline{q}_{j,i}+q_{j,k}+q_{j,i+1}}{i+2} - q_{j,i+1}) - (q_{j,i+1} - (\frac{\overline{q}_{j,i}+q_{j,i}+q_{j,i+1}}{i+1} - q_{j,i+1}) - q_{j,i+1})) = \frac{q_{j,k}-q_{j,i}}{i+2}$.

The expected quality $q_{j,i+3}$ in period $i+3$ rises by: $\frac{q_{j,k}-q_{j,i}}{i+3}$, and so on.

The expected quality $q_{j,k+1}$ in period $k+1$ rises by:
$q_{j,i} - (\overline{q}_{j,k+1} - q_{j,i}) - (q_{j,k} - (\overline{q}_{j,k+1} - q_{j,k}) = -2 * (q_{j,k} - q_{j,i})$.

If we sum over the increases of expected qualities $q_{j,i+1}, .., q_{j,k+1}$, we get $2 * (q_{j,k} - q_{j,i}) + \frac{q_{j,k}-q_{j,i}}{i+1} + \frac{q_{j,k}-q_{j,i}}{i+2} + \frac{q_{j,k}-q_{j,i}}{i+3} ... + \frac{q_{j,k}-q_{j,i}}{k} - 2*(q_{j,k}-q_{j,i}) = \frac{q_{j,k}-q_{j,i}}{i+1} + \frac{q_{j,k}-q_{j,i}}{i+2} + \frac{q_{j,k}-q_{j,i}}{i+3} ... + \frac{q_{j,k}-q_{j,i}}{k}$.

As we required that $q_{j,k} > q_{j,i}$, every summand is positive and therefore the sum. Therefore, the probability that physician D_j gets selected in periods $i+2,..,k$ rises, while the changes in probability in periods i and k neutralize each other. By deviating to this strategy, the physician improves their expected profits, which is a contradiction to $((\hat{q}_{1,1}, \hat{q}_{2,1}, c_1), .., (\hat{q}_{1,T}, \hat{q}_{2,T}, c_T))$ being a subgame perfect Nash equilibrium. □

B.8 Proof of Lemma 3.7

Proof of Lemma 3.7. We start by calculating the expected profit of physician D_1 in the next $(T-t+1)$ periods for playing the strategy vector $(100, 100, .., \max\{20, \frac{100\alpha_1}{1+\alpha_1}\})$.

$\sum_{i=t}^{T-t+1} \mathbb{E}(U_1(q^*_{1,t})) = \sum_{i=t}^{T-t+1} P(D_1 \textit{ gets selected in period } t) * (200 + 4\alpha_1 q^*_{1,t} - (0.02 + 0.02\alpha_1) * (q^*_{1,t})^2) = (T-t) * \frac{1}{2} * 200\alpha_1 + \frac{1}{2} * (200 + 4\alpha_1 * 100 - (0.02 + 0.02\alpha_1) * (100)^2) + \frac{1}{2} * (200 + 4\alpha_1 * \max\{20, \frac{100\alpha_1}{1+\alpha_1}\} - (0.02 + 0.02\alpha_1) * (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\})^2) = (T-t) * 100\alpha_1 + 100 + 2\alpha_1 * \max\{20, \frac{100\alpha_1}{1+\alpha_1}\} - (0.01 + 0.01\alpha_1) * (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\})^2$

Now, we have to check whether there is a strategy vector providing a strictly higher expected utility. According to Lemma 3.2, there is no incentive to deviate in period T.

If we assume $\exists\, k \in \{1, .., T-1\}$ with $q_{1,k} \neq 100$, we know that $\forall t \in \{k+1, .., T\}$ it holds $P(D_1 \textit{ gets chosen in period } t) = 0$. It follows that $\sum_{i=k}^{k} \frac{1}{2} * (200 + 4\alpha_1 * \max\{20, \frac{100\alpha_1}{1+\alpha_1}\} - (0.02 + 0.02\alpha_1) * (\max\{20, \frac{100\alpha_1}{1+\alpha_1}\})^2) + \sum_{i=k+1}^{T} 0$ is physician D_1's expected profit after deviating, which is strictly less than the expected profit for not deviating if $\alpha_1 > 0$. Please note that choosing a quality $q_{1,k} \neq \max\{20, \frac{100\alpha_1}{1+\alpha_1}\}$ even leads to a smaller expected utility. If $\alpha_1 = 0$, the expected utilites for deviating and not deviating from the equilibrium strategy are equal. For both, $\alpha_1 > 0$ and $\alpha_1 = 0$, there is no incentive to deviate. This holds analogous for physician D_2 and patient P also has no incentive to deviate because expected patient benefit strictly decreases in travel costs. □

If we set $k = 1$ and $\alpha_1 = 0$ in the previous proof, it leads us to the conclusion that $((20, 100, D_1), (20, 100, D_2).., (20, \max\{20, \frac{100\alpha_2}{1+\alpha_2}\}, D_2))$ is a Nash equilibrium as well.

B.9 Additional Lemmas and Proofs of Section 3.3

Lemma B.2. Be $((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ a subgame perfect Nash equilibrium, with $P(D_1 \textit{ gets selected in period } T) = 0$.
$\longrightarrow ((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ is a subgame perfect Nash equilibrium $\forall \hat{q}_{1,T} \in [20, 100]$ with $\hat{q}_{1,T} \neq q^*_{1,T}$.

Proof. Be $((q^*_{1,1}, q^*_{2,1}, c^*_1), .., (q^*_{1,T}, q^*_{2,T}, c^*_T))$ a subgame perfect Nash equilibrium, with $P(D_1 \textit{ gets selected in period } T) = 0$.

Let us check whether $(\hat{q}_{1,T}, q^*_{2,T}, c^*_T)$ is a Nash equilibrium in period T. There is no incentive for D_1 to deviate to $\tilde{q}_{1,T} \in [20, 100]$, with $\tilde{q}_{1,T} \neq \hat{q}_{1,T}$.
$\longleftrightarrow \mathbb{E}(U_1(\hat{q}_{1,T}, q^*_{2,T})) \geq \mathbb{E}(U_1(\tilde{q}_{1,T}, q^*_{2,T}))\ \forall \hat{q}_{1,T} \in [20, 100]$ with $\tilde{q}_{1,T} \neq \hat{q}_{1,T}$
$\longleftrightarrow P(D_1 \textit{ gets selected in period } T) * (200 + 4\alpha_1 \hat{q}_{1,T} - (0.02 + 0.02\alpha_1) * (\hat{q}_{1,T})^2) \geq$
$P(D_1 \textit{ gets selected in period } T) * (200 + 4\alpha_1 \tilde{q}_{1,T} - (0.02 + 0.02\alpha_1) * (\tilde{q}_{1,T})^2)$
As $P(D_1 \textit{ gets selected in period } T) = 0$ per assumption, we know that

$\longleftrightarrow 0 \geq 0$
This condition is true.

D_2 has also no incentive to deviate from the chosen quality $q_{2,T}$. Either $P(D_2 \textit{ gets selected in period } T) = 0$. Then, we reason analogous to the former case. Or $P(D_2 \textit{ gets selected in round } T) > 0$. In this case, there is also no incentive to deviate, using Lemma 3.4 and arguing as in the proof of Lemma 3.2. Patient P also has no incentive to deviate from the chosen physician c_T^*, because their choice of a physician is only based on travel costs and on the qualities chosen by physicians in *previous* periods.
$\longrightarrow (\hat{q}_{1,T}, q_{2,T}^*, c_T^*)$ is a Nash equilibrium in period T.
$\longrightarrow ((q_{1,1}^*, q_{2,1}^*, c_1^*), .., (q_{1,T}^*, q_{2,T}^*, c_T^*))$ is a subgame perfect Nash equilibrium.

Since we do not specify $\hat{q}_{1,T}$, we know that this holds $\forall \hat{q}_{1,T} \in [20, 100]$. For simplicity, we proved this Lemma for physician D_1 but the proof is analagous for physician D_2. □

Lemma B.3. Be $((q_{1,1}^*, q_{2,1}^*, c_1^*), .., (q_{1,T}^*, q_{2,T}^*, c_T^*))$ a subgame perfect Nash equilibrium. We further require that $\exists k \in \{1, .., T\}$ with $P(D_1 \textit{ gets selected in period } t) = 0 \ \forall t \in \{k, .., T\}$.
$\longrightarrow ((q_{1,1}^*, q_{2,1}^*), .., (q_{1,T}^*, q_{2,T}^*))$ is a subgame perfect Nash equilibrium $\forall \hat{q}_{1,k}, .., \hat{q}_{1,T} \in [20, 100]^{T-k+1}$ with $\hat{q}_{1,t} \neq q_{1,t}^* \forall t \in \{k, .., T\}$.

Proof. Be $((q_{1,1}^*, q_{2,1}^*, c_1^*), .., (q_{1,T}^*, q_{2,T}^*, c_T^*))$ a subgame perfect Nash equilibrium and we require $\exists k \in \{1, .., T\}$ with $P(D_1 \textit{ gets selected in period } t) = 0 \ \forall t \in \{k, .., T\}$.

Let us check whether $(\hat{q}_{1,t}, q_{2,t}^*, c_t^*)$ is a Nash equilibrium in period t. There is no incentive for D_1 to deviate to $\tilde{q}_{1,t}, .., \tilde{q}_{1,T} \in [20, 100]^{T-t+1}$, with $\tilde{q}_{1,t} \neq \hat{q}_{1,t} \forall j \in \{t, ..T\}$.
$\longleftrightarrow \sum_{i=t}^{T} \mathbb{E}(U_1(\hat{q}_{1,i}, q_{2,i}^*)) \geq \sum_{i=t}^{T} \mathbb{E}(U_1(\tilde{q}_{1,i}, q_{2,i}^*))$
$\forall \hat{q}_{1,t}, .., \hat{q}_{1,t} \in [20, 100]^{T-t+1}$ with $\tilde{q}_{1,j} \neq \hat{q}_{1,j} \forall j \in \{t, ..T\}$
$\longleftrightarrow \sum_{i=t}^{T} P(D_1 \textit{ gets selected in period } i) * (200 + 4\alpha_1 \hat{q}_{1,i} - (0.02 + 0.02\alpha_1) * (\hat{q}_{1,i})^2)$
$\geq \sum_{i=t}^{T} P(D_1 \textit{ gets selected in period } i) * (200 + 4\alpha_1 \tilde{q}_{1,i} - (0.02 + 0.02\alpha_1) * (\tilde{q}_{1,i})^2)$

Since $P(D_1 \textit{ gets selected in period } t) = 0$ per assumption $\forall t \in \{k, .., T\}$, we know that
$\longleftrightarrow 0 \geq 0$
This condition is true.

D_2 has also no incentive to deviate from the chosen quality $q_{2,t}$ in period t because they are not informed about D_1's quality choices. So D_2's optimal quality choices only depend on the quality choices they *expect* from D_1.
$\longrightarrow (\hat{q}_{1,t}, q_{2,t}^*, c_t^*)$ is a Nash equilibrium in period $t \ \forall t \in \{k, .., T\}$.
$\longrightarrow ((q_{1,1}^*, q_{2,1}^*, c_1^*), .., (q_{1,T}^*, q_{2,T}^*, c_T^*))$ is a subgame perfect Nash equilibrium.

Since we do not specify $\hat{q}_{1,t}, .., \hat{q}_{1,T}$, we know that this holds $\forall \hat{q}_{1,t} \in [20, 100]^{T-t+1}$. This can again be proven analogously for physician D_2. □

C Additional regression results and figures

Table C.1: Conditional logistic regressions on patients' choices in periods $t \in \{2, ..., 40\}$

	Baseline	R	N-M	R-M
	(1)	(2)	(3)	(4)
travel_costs	-0.113^{***}	-0.074^{***}	-0.091^{***}	-0.084^{***}
	(0.008)	(0.007)	(0.007)	(0.008)
average_quality		0.105^{***}		0.134^{***}
		(0.010)		(0.013)
last_quality		0.002		0.022^{***}
		(0.005)		(0.007)
empty			-0.568^{***}	-0.302
			(0.201)	(0.228)
social_proximity			0.570^{***}	-0.208
			(0.156)	(0.181)
promise			1.044^{***}	0.733^{***}
			(0.195)	(0.203)
Observations	780	780	780	780
McFadden's R^2	0.332	0.334	0.277	0.502

Note: Each observation represents a patient's choice. The dependent variable is an indicator which equals 1 if physician D_j was chosen. We include observations from periods $t \in \{2, ..., 40\}$. Standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table C.2: Conditional logistic regressions on patients' choices in periods $t \in \{2, ..., 20\}$

	Baseline (1)	R (2)	N-M (3)	R-M (4)
travel_costs	-0.104^{***}	-0.097^{***}	-0.116^{***}	-0.066^{***}
	(0.011)	(0.012)	(0.012)	(0.011)
average_quality		0.131^{***}		0.135^{***}
		(0.017)		(0.017)
last_quality		0.003		0.008
		(0.008)		(0.009)
empty			-0.922^{***}	-0.295
			(0.336)	(0.315)
social_proximity			0.673^{***}	-0.121
			(0.251)	(0.256)
promise			0.758^{**}	0.563^{**}
			(0.295)	(0.275)
Observations	380	380	380	380
McFadden's R^2	0.286	0.434	0.344	0.459

Note: Each observation represents a patient's choice. The dependent variable is an indicator which equals 1 if physician D_j was chosen. We include only observations from periods $t \in \{2, ..., 20\}$. Standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table C.3: Conditional logistic regressions on patients' choices in periods $t \in \{21, ..., 39\}$

	Baseline (1)	R (2)	N-M (3)	R-M (4)
travel_costs	-0.126^{***}	-0.060^{***}	-0.082^{***}	-0.108^{***}
	(0.013)	(0.009)	(0.010)	(0.014)
average_quality		0.089^{***}		0.125^{***}
		(0.013)		(0.021)
last_quality		0.002		0.051^{***}
		(0.006)		(0.013)
empty			-0.469^{*}	-0.355
			(0.264)	(0.349)
social_proximity			0.447^{**}	-0.252
			(0.210)	(0.269)
promise			1.221^{***}	0.978^{***}
			(0.278)	(0.317)
Observations	380	380	380	380
McFadden's R^2	0.365	0.253	0.243	0.553

Note: Each observation represents a patient's choice. The dependent variable is an indicator which equals 1 if physician D_j was chosen. We include only observations from periods $t \in \{21, ..., 39\}$. Standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Table C.4: Mixed model regressions on patient benefits in periods $t \in \{2, ..., 39\}$

	all	Baseline	R	N-M	R-M
	(1)	(2)	(3)	(4)	(5)
quality	1.699***	1.877***	1.629***	1.625***	1.554***
	(0.010)	(0.019)	(0.017)	(0.020)	(0.020)
travel_costs	−0.997***	−1.010***	−0.986***	−0.988***	−0.996***
	(0.011)	(0.025)	(0.022)	(0.019)	(0.019)
reputation	3.486***				
	(1.087)				
physician_messages	−0.263				
	(1.083)				
empty				0.996	−1.127
				(1.156)	(0.863)
social_proximity				0.020	0.962
				(0.661)	(0.726)
promise				2.710**	0.333
				(1.073)	(0.991)
period	−0.016	−0.048**	0.039*	−0.082***	0.031
	(0.011)	(0.023)	(0.022)	(0.017)	(0.019)
female	1.163	0.317	0.181	3.876	−1.047
	(1.084)	(2.059)	(0.986)	(3.646)	(1.013)
svo_angle	0.067**	0.056	0.012	0.089	0.032
	(0.029)	(0.046)	(0.029)	(0.124)	(0.028)
Constant	55.136***	47.381***	62.659***	57.244***	69.092***
	(1.355)	(2.139)	(1.703)	(3.486)	(1.941)
Observations	3,040	760	760	760	760
Log Likelihood	-10,135.620	-2,585.081	-2,537.696	-2,412.241	-2,425.487
Akaike Inf. Crit.	20,291.240	5,186.163	5,091.392	4,846.483	4,872.974
Bayesian Inf. Crit.	20,351.430	5,223.229	5,128.458	4,897.449	4,923.940

Note: Results from linear mixed-model regressions with patient benefit as dependent variable. We include only observations from periods $t \in \{2, ..., 39\}$. As independent variables, we include variables for the treatment quality provided by the chosen physician and the travel costs. In model 1, we include dummy variables for reputation information and physician messages. In models 4 and 5, we include variables referring to attributes of the chosen physician's message. In order to control for personal characteristics of subjects in the role of physicians, we include a dummy variable for female physicians and the social value orientation angle calculated based on subjects' decisions in the second part of the experiment. Standard errors are reported in parentheses. $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

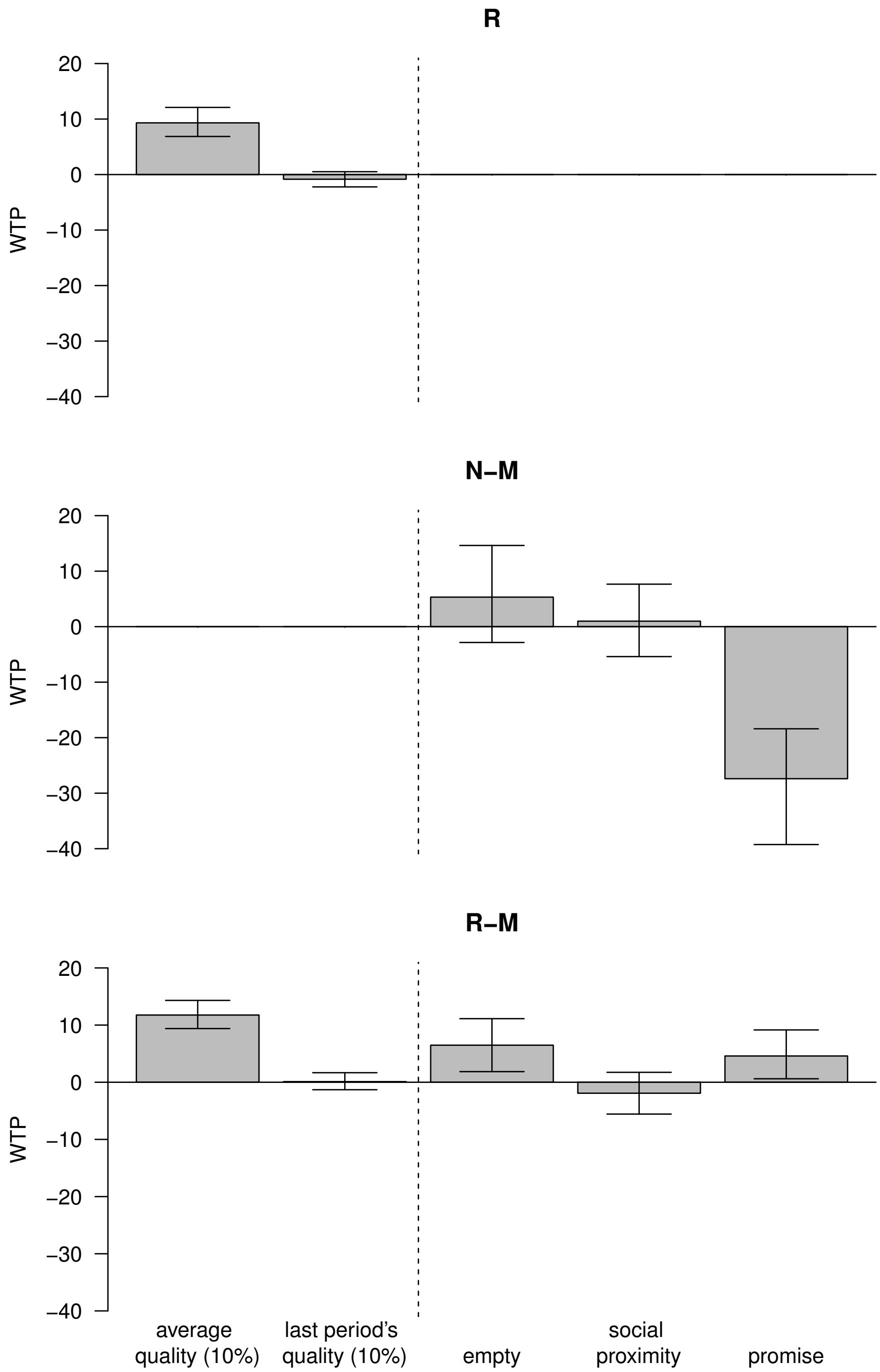

Figure C.1: Patients' willingness to invest travel costs based on correct expectations minus observed willingness to invest travel costs (95 percent bootstrapped confidence intervals)

Chapter 3

Resource scarcity and prioritization decisions in medical care: A lab experiment with heterogeneous patient types

Reference

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Resource scarcity and prioritization decisions in medical care: A lab experiment with heterogeneous patient types

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[Correction added on 30 November 2020, after first online publication: The university name in the second affiliation and the footnote citations in Table 2 have been updated in this version.]

Abstract

During the COVID-19 pandemic, health care systems around the world have received additional funding, while at other times, financial support has been lowered to consolidate public spending. Such budget changes likely affect provision behavior in health care. We study how different degrees of resource scarcity affect medical service provision and, in consequence, patients' health. In a controlled lab environment, physicians are paid by capitation and allocate limited resources to several patients. This implies a trade-off between physicians' profits and patients' health benefits. We vary levels of resource scarcity and patient characteristics systematically and observe that most subjects in the role of physician devote a relatively stable share of budget to patient treatment, implying that they provide fewer services when they face more severe budget constraints. Average patient benefits decrease in proportion to physician budgets. The majority of subjects chooses an allocation that leads to equal patient benefits as opposed to allocating resources efficiently.

KEYWORDS

laboratory experiment, physician behavior, prioritization, resource scarcity, social preferences

JEL CLASSIFICATIONS

C91, D64, I11

1 | INTRODUCTION

Although cutbacks in social welfare spending can affect public health outcomes negatively (e.g., Kmietowicz, 2016; Stuckler, Basu, & McKee, 2010a, 2010b), some countries reduce public spending by lowering financial support for health care providers. Some European countries reduced health care providers' pay after the financial crisis, for example (Mladovsky et al., 2012; Quaglio, Karapiperis, van Woensel, Arnold, & McDaid, 2013). On the other hand, many European countries are now planning to increase health care spending including payments to providers in response to the COVID-19 pandemic (Thomson, Habicht, & Evetovits, 2020). Either way, a change in payments is likely to alter physicians' provision behavior and, thus, affect patients' health outcomes.

In a stylized lab experiment, we explore the causal link between both, degrees of resource scarcity and patient characteristics, and medical service provision under capitation payment. In the field, it would be difficult to isolate effects of physician budgets and patient characteristics from other potential influences.[1] Therefore, we use a controlled lab environment that allows ceteris paribus variations of the levels of physician budget and patient characteristics (for a general discussion of the experimental method see, e.g., Fréchette & Schotter, 2015, and for a discussion of health economics experiments see Galizzi & Wiesen, 2018). Overall, our study contributes to previous literature in three aspects as follows: (1) We systematically vary the degree of resource scarcity in order to investigate its influence on the provision and allocation of medical care, (2) Our setting involves resource rivalry among heterogeneous patients. This allows studying how patient characteristics influence the allocation of resources, and (3) Using a within-subject design, we are able to account for variations in physicians' decision-making.

So far, only few studies investigate how different levels of payment affect physicians' decisions. Clemens and Gottlieb (2014), for example, analyze US data and find that a 2% increase in payment rates for medical services translates into a 3% increase in care provision on average. In controlled lab experiments, Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, and Wiesen (2013) and Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, Kokot, and Wiesen (2019) observe no significant differences in provision behavior between two different capitation payments. In contrast to our experiment, physicians allocate services to only one patient at a time in their experiments, though. As physicians frequently allocate resources to several patients, it is important to investigate effects of resource scarcity in settings that can lead to a trade-off between several — possibly heterogeneous — patients.[2] Similar to our study, Ahlert, Felder, and Vogt (2012) and Di Guida, Gyrd-Hansen, and Oxholm (2019) experimentally study allocation decisions in settings with multiple patients. Ahlert et al. (2012) observe that physicians treat fewer patients and give a lower share of their budget to patients as it decreases. Their payment scheme does not involve a trade-off between physician profit and patient benefit, though. Di Guida et al. (2019) implement a fee-for-service payment with varying fee levels and ask their participants to assign a limited number of services to one or two patients. They find that a lower fee reduces overprovision when physicians face patients with relatively low optimal service quantities. In contrast to Ahlert et al. (2012) and Di Guida et al. (2019), we implement a capitation payment while systematically analyzing the effects of different budget levels and patient characteristics on medical service provision. The experimental setting is presented in Section 2. Section 3 summarizes our main findings and Section 4 concludes.

2 | EXPERIMENT

2.1 | Experimental design

Our within-subject design extends the design of earlier health economics experiments (e.g., Brosig-Koch et al., 2019; Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, & Wiesen, 2016; 2017; Martinsson & Persson, 2019; Wang, Iversen, Hennig-Schmidt, & Godager, 2020) by (1) including a second patient in the physician's allocation decision[3] and by (2) systematically varying the physician's budget. In our medically framed experiment, subjects take the role of physicians and patients and keep their assigned role throughout the entire experiment.[4] One subject in the role of physician faces the same two subjects in the role of patients over the course of 27 periods.[5] In each period, the physician receives a budget and determines the quantity of medical services q_j allocated to each of the two patients $j \in \{1,2\}$. While physicians face convex costs for treatment in most health economics experiments (e.g., Brosig-Koch et al., 2016; 2017; Brosig-Koch et al., 2019; Hennig-Schmidt, Selten, & Wiesen, 2011; Martinsson & Persson, 2019; Wang et al., 2020), some experimental studies assume linear costs (e.g., Kesternich, Schumacher, & Winter, 2015; Reif, Hafner, & Seebauer, 2020). We follow the latter approach and implement linear costs $c = 1$ per medical service in order to keep the decision situation as simple as possible. Physician profit is specified as

$$\pi(q_1, q_2) = \text{budget} - (q_1 + q_2).$$

Patient health benefit $b_j\ (q_j)$ increases with the quantity of medical services q_j, depending on the marginal health benefit $\theta_j \in \{0.5,1,2\}$. For medical service quantities exceeding the optimal quantity $q_j^* \in \{10,15,20\}$, patients neither experience a decrease in benefit nor gain further benefits:

$$b_j\left(q_j\right)\begin{cases} \theta_j q_j \ \ if\ q_j < q_j^* \\ \theta_j q_j^* \ if\ q_j \geq q_j^* \end{cases}.$$

TABLE 1 Patient characteristics in the nine combinations of patient types

Combination of patient types	Patient 1	Patient 2	$q_1^* + q_2^*$
1	*Ay*: $\theta_1 = 0.5$, $q_1^* = 15$	*Ay*: $\theta_2 = 0.5$, $q_2^* = 15$	30
2	*By*: $\theta_1 = 1$, $q_1^* = 15$	*By*: $\theta_2 = 1$, $q_2^* = 15$	30
3	*Cy*: $\theta_1 = 2$, $q_1^* = 15$	*Cy*: $\theta_2 = 2$, $q_2^* = 15$	30
4	*Ay*: $\theta_1 = 0.5$, $q_1^* = 15$	*By*: $\theta_2 = 1$, $q_2^* = 15$	30
5	*By*: $\theta_1 = 1$, $q_1^* = 15$	*Cy*: $\theta_2 = 2$, $q_2^* = 15$	30
6	*Ay*: $\theta_1 = 0.5$, $q_1^* = 15$	*Cy*: $\theta_2 = 2$, $q_2^* = 15$	30
7	*Ax*: $\theta_1 = 0.5$, $q_1^* = 10$	*Bz*: $\theta_2 = 1$, $q_2^* = 20$	30
8	*Bx*: $\theta_1 = 1$, $q_1^* = 10$	*Cz*: $\theta_2 = 2$, $q_2^* = 20$	30
9	*Ax*: $\theta_1 = 0.5$, $q_1^* = 10$	*Cz*: $\theta_2 = 2$, $q_2^* = 20$	30

We define nine combinations of patient types with varying combinations of patient characteristics (see Table 1). In combinations one to three, both patients have the same marginal benefits and optimal quantities. In combinations four to nine, we mix different patient types: patient 2 has a higher marginal benefit than patient 1. The experiment is conducted once with each combination of patient types and each of the three budgets ϵ {20,30,45}. We use these three levels of budget because first, these values are considerably different from each other and second, they imply a significant variation in the constraints for optimal treatment since the sum of optimal service quantities is constant at $q_1^*+q_2^* = 30$ throughout all decision scenarios.

Under the assumption of rationality and selfishness, physicians should keep the whole budget to maximize their own profit. However, previous experimental studies provide evidence that subjects systematically deviate from selfish behavior (e.g., Brosig-Koch et al., 2016; Di Guida et al., 2019; Hennig-Schmidt et al., 2011). Our experiment is designed such that it furthermore allows to distinguish between the three main allocation principles based on medical need (e.g., Culyer & Wagstaff, 1993; Williams & Cookson, 2000; see also Martinsson & Persson, 2019):

1. **Equal health outcomes**: This principle is based on everyone's right to a normal life span with a good quality of life (Williams, 1997). It implies providing the same health outcomes ($b_1 = b_2$) for both patients.
2. **Severity of illness**: According to this principle, patients should be prioritized based on their initial level of illness. Since both patients share the same severity (0) in all combinations of patient types, this implies allocating the same service quantities ($q_1 = q_2$) to both patients.
3. **Capacity to benefit**: This principle entails that priority should be given to patients who benefit the most from treatment. It translates into giving a higher quantity to the patient with the higher marginal benefit, that is, patient 2 ($q_1<q_2$).

2.2 | Experimental procedures

The computerized experiment was programmed with z-Tree (Fischbacher, 2007) and conducted at the Essen Laboratory for Experimental Economics (*elfe*). We used ORSEE (Greiner, 2015) to recruit 174 participants.[6] Several experimental studies investigate if medical or non-medical students and physicians differ in their behavioral reactions to changes in decision settings (e.g., Brosig-Koch et al., 2016; Brosig-Koch et al., 2017; Hennig-Schmidt & Wiesen, 2014; see Galizzi & Wiesen, 2018 for a short discussion). Even though the intensity of behavioral changes might vary between participant groups, they show qualitatively similar responses to changes. We chose a conventional subject pool for our study which allowed us to identify behavioral responses to different levels of resource scarcity but not to estimate effect sizes. Nevertheless, we had 13 medical students in the role of physicians. Since we found no qualitative differences in behavior between the 13 medical and the 45 non-medical students in the role of physicians, we pooled the observations from both groups for the results reported in the next section.

The order of the 27 decision scenarios was randomly selected and kept constant for all sessions. Note that using the same order for all subjects may lead to an order effect. However, based on findings in health economics experiments, we

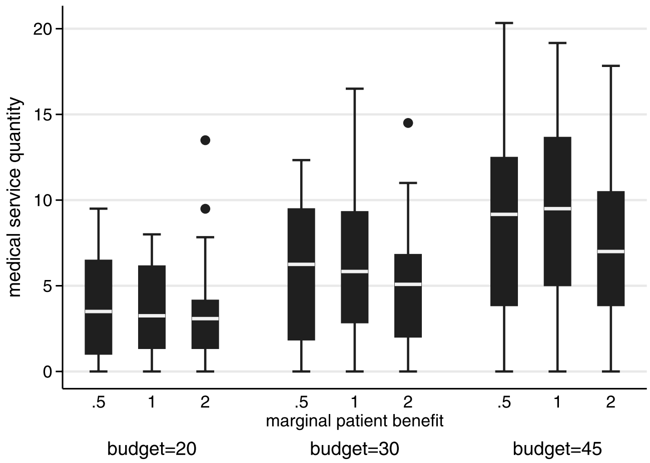

FIGURE 1 Boxplots for provided medical service quantities by budget and marginal patient benefit; This figure shows boxplots for the provided medical service quantities separately for the three marginal patient benefits within the three levels of budget. The gray boxes mark the interval from the 25th to the 75th percentile with the bright line indicating the median. The whiskers give the range of adjacent values while the dots represent outliers

expected to observe variation in physicians' allocation behavior (Brosig-Koch et al., 2017; Godager & Wiesen, 2013; Li, Dow, & Kariv, 2017) and wanted to avoid additional differences through heterogeneous order effects. Moreover, experimental studies report mixed evidence with a tendency toward the absence of order effects in health contexts (see Brosig-Koch et al., 2019; Buckley et al., 2015, 2016; but Wang, Iversen, Hennig-Schmidt, & Godager, 2017). Subjects were informed in the instructions that one period would be randomly chosen for payment (see Appendix B for the instructions). All amounts were given in tokens which were converted to Euro at an exchange rate of 1 token = 1.00 Euro at the end of the experiment. As second part of the experiment, we implemented the Social Value Orientation slider (Murphy, Ackermann, & Handgraaf, 2011). After the second part of the experiment, we asked subjects to complete a short questionnaire which contained questions on trust and inequality (based on the European Values Study, 2020) and questions on demographics (age, gender, nationality, and field of study). The ten experimental sessions were conducted between November and December 2016 as well as in December 2017. Each of the sessions lasted 1.5 h at most and subjects earned 19.50 Euro on average.

3 | RESULTS

In this section, we analyze how the 58 subjects in the role of physicians allocate the budget between themselves and the two passive patients.[7] First, we look at the number of selfish decisions ($q_1 = q_2 = 0$) and optimally treated patients ($q_j = q_j^*$) for each level of budget. We observe that physicians more often allocate resources selfishly with an increasing degree of resource scarcity (*budget* = 20: 18.6%, *budget* = 30: 13.4%, *budget* = 45: 10.0%, $p \leq 0.082$, pairwise Wilcoxon matched-pairs signed rank tests). Concurrently, the number of optimally treated patients decreases with resource scarcity (*budget* = 20: 1.1%, *budget* = 30: 7.5%, *budget* = 45: 24.1%, $p < 0.001$; see also Table A3 in Appendix A). Boxplots for the quantity of provided medical services by physician budget and marginal patient benefit are shown in Figure 1 (average values are in Table A4 in Appendix A).

The number of services provided increases with physicians' budget. This is confirmed by ordinary least-squares regressions in which we control for physicians' personal characteristics and other influences.[8] The share of budget that physicians devote to patient treatment, the *services-budget-ratio* ($\gamma = (q_1 + q_2)/budget$), remains remarkably stable across the three budget levels on average (*budget* = 20: 35.4%, *budget* = 30: 37.2%, *budget* = 45: 36.3%; $p \geq 0.338$, pairwise Wilcoxon matched-pairs signed rank tests; see also Figure A1 and Table A6 in Appendix A). As depicted in Figure A2 in Appendix A, the individual services-budget-ratios vary widely between physicians, though. To examine physicians' different reactions to budget variations in more detail, we compare the average services-budget-ratio by budget for each subject. We observe that 35 physicians change their (positive) services-budget-ratio by less than 10 percentage points between the different levels of budget.[9] For the remaining physicians, we find no clear direction of the effect. Six physicians decrease their services-budget-ratio by more than 10 percentage points when the budget is

TABLE 2 Classification of decisions and subjects

		N	Selfishness $q_1 = q_2 = 0$	Equal benefits $b_1 = b_2$	Equal quantities $q_1 = q_2$	Efficiency $q_1 < q_2$
All	# of decisions	1044	135 (12.9%)	473 (45.3%)	406 (38.9%)	255 (24.4%)
	# of subjects with >50% decisions	58	6 (10.3%)	26 (44.8%)	16[a] (27.6%)	10 (17.2%)
	subject id		*2, 7, 16, 36, 45, 58*	*4, 9, 14, 17, 18, 19, 23, 24, 27, 28, 30, 31, 33, 34, 37, 39, 40, 41, 44, 47, 48, 50, 52, 53, 56, 57*	*1, 3, 6, 20, 21, 22, 24, 27, 29, 30, 32, 42, 49, 51, 55, 56*	*1, 6, 8, 11, 12, 13, 35, 43, 54, 55*
budget = 20	# of decisions	348	59 (17.0%)	130 (37.4%)	128 (36.8%)	65 (18.7%)
	# of subjects with >50% decisions	58	9 (15.5%)	19 (32.8%)	18[b] (31.03%)	8 (13.8%)
	subject id		*2, 7, 16, 25, 26, 36, 45, 46, 53*	*9, 18, 22, 23, 27, 30, 31, 32, 33, 34, 39, 40, 41, 44, 48, 50, 52, 57, 58*	*1, 3, 5, 6, 10, 12, 20, 21, 22, 24, 27, 29, 30, 32, 43, 49, 51, 55*	*8, 11, 12, 13, 35, 43, 49, 54*
budget = 30	# of decisions	348	45 (12.9%)	161 (46.3%)	113 (32.5%)	69 (19.8%)
	# of subjects with >50% decisions	58	6 (10.3%)	26 (44.8%)	10[c] (17.2%)	9 (15.5%)
	subject id		*2, 7, 16, 36, 45, 58*	*9, 14, 17, 18, 19, 22, 23, 24, 27, 28, 30, 31, 32, 33, 34, 37, 39, 40, 41, 44, 46, 48, 49, 50, 52, 53*	*20, 21, 22, 24, 25, 27, 30, 32, 42, 51*	*1, 8, 11, 12, 13, 15, 35, 54, 55*
budget = 45	# of decisions	348	31 (8.9%)	182 (52.3%)	165 (47.4%)	121 (34.8%)
	# of subjects with >50% decisions	58	5 (8.6%)	29 (50.0%)	24[d] (41.4%)	13 (22.4%)
	subject id		*2, 7, 16, 36, 58*	*4, 6, 8, 11, 14, 17, 18, 19, 23, 24, 28, 29, 31, 33, 34, 37, 38, 39, 40, 41, 42, 44, 47, 48, 50, 52, 53, 56, 57*	*4, 6, 8, 9, 11, 15, 20, 22, 23, 24, 25, 28, 29, 30, 31, 32, 38, 42, 47, 50, 51, 52, 56, 57*	*6, 8, 11, 13, 23, 29, 31, 38, 42, 43, 55, 56, 57*

Note: The first row in each cell gives the number of decisions which are consistent with an allocation principle. The second row gives the number of subjects who decide in line with an allocation type in more than 50% of decisions. Due to the capped patient benefit function and tolerance, decisions may be consistent with more than one principle and subjects may fall into more than one category or none at all. Therefore, percentages might not horizontally sum up to 100%. Italic numbers give the id of subjects who fall into a category.

[a]Four subjects fall into the categories *equal quantities* and *equal benefits*, three subjects fall into the categories *equal quantities* and *efficiency*.

[b]Four subjects fall into the categories *equal quantities* and *equal benefits*, three subjects fall into the categories *equal quantities* and *efficiency*.

[c]Five subjects fall into the categories *equal quantities* and *equal benefits*.

[d]Sixteen subjects fall into the categories *equal quantities* and *equal benefits*, ten of these subjects also fall into the category *efficiency*.

lowered. This might be interpreted as a strategy of target income. In contrast, 11 physicians increase the services-budget-ratio when resources are more constrained. These subjects seem to give up some of their own profit to compensate for the lower budget level.

Next, we analyze how physicians allocate resources between heterogeneous patient types. Following the prioritization principles based on medical need (see Section 2.1), we consider *equal benefits*, *equal quantities*, and *efficiency* besides selfish decision-making (see Table A1 in Appendix A for predictions). For the analysis, we restrict the data to patient combinations four to nine since predictions for *equal benefits* and *equal quantities* are exactly the same and there are no predictions for *efficiency* in combinations one to three. We allow a tolerance of one unit of medical services for *equal benefits* and *equal quantities*.[10] Table 2 summarizes the classification results.

Overall, 32 physicians decide in line with one of the two *equality* principles in at least two budget conditions. The majority of these subjects decides in line with *equal benefits*. The trend that *equal benefits* is most often applied persists in all three budget conditions. Considering only decision-making in the high budget condition, 121 observations (34.8%) with heterogeneous patient types fall into more than one category. This problem arises because predictions for several principles coincide for a provided sum of 20 or more services. Therefore, we only compare the low and intermediate budget levels. We observe that, as physician budget decreases, fewer physicians choose *equal benefits* ($p = 0.022$, exact McNemar's test) and more decide in line with *equal quantities* ($p = 0.039$).[11] On an aggregate level, the average health benefit generated per unit of available budget differs between the low and intermediate budget conditions for patients with $\theta_j = 1$ ($budget = 20$: 0.182, $budget = 30$: 0.198, $p = 0.056$, Wilcoxon matched-pairs signed rank test) but not for the other patient types ($\theta_j = 0.5$: $p = 0.966$, $\theta_j = 2$: $p = 0.151$; all values are in Table A7 in Appendix A). Consequently, the increase in resource scarcity leads to a proportional decrease of average patient benefits.

4 | CONCLUSION

We investigate how different degrees of resource scarcity and patient characteristics influence medical service provision under capitation payment. In our experiment, most subjects in the role of physicians provide constant shares of their budgets to patient care and, thus, fewer services when they face more severe budget constraints. With respect to the allocation of resources between patients, the largest group of physicians provides equal patient benefits. On an aggregate level, patient benefits decrease in proportion to the increase in resource scarcity. On the individual level, we observe a considerable degree of heterogeneity in decision patterns, though, which is in line with findings from other health economics experiments (Brosig-Koch et al., 2017; Godager & Wiesen, 2013; Li et al., 2017).

Our findings indicate that — despite a considerable degree of non-selfish decisions — a change in the size of a physician's budget may lead to a proportional shift in patients' health outcomes. Of course, one has to be careful when transferring findings from the lab to the field, but our experimental results provide valuable guidance by disclosing possible impacts of budget changes on allocation behavior in medical care.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

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ENDNOTE

1 For example, patient characteristics such as comorbidities may not be objectively observable in a natural setting. Furthermore, physicians could face uncertainties regarding their budget and the effectiveness of treatment.

2 Theoretically, numerous principles exist for prioritizing resources among patients (Golan, Hansen, Kaplan, & Tal, 2011; Sabik & Lie, 2008; Shah, 2009). While survey respondents seem to prefer equality over efficiency (e.g., Ahlert & Schwettmann, 2017; Attema, Brouwer, l'Haridon, & Pinto, 2015), participants in health economics experiments do not seem to share a clear preference for equality (e.g., Ahlert et al., 2012; Ahlert, Funke, & Schwettmann, 2013; Di Guida et al., 2019; Martinsson & Persson, 2019).

3 Ahlert et al. (2012) and Di Guida et al. (2019) also study physician provision behavior in settings with multiple patients. In contrast to their experiments, we implement a capitation payment scheme. More generally, one could argue that the treatment of two patients involves two simultaneous decisions. Two simultaneous tasks for physicians are also implemented in other experiments. For example, Reif et al. (2020)

let physicians (1) request a budget from a health insurance and (2) decide about patient treatment, and Waibel and Wiesen (2019) ask physicians to (1) diagnose the patient and (2) decide about referring him to a specialist.

[4] In health economics experiments, patient benefit is either donated to a charity caring for actual patients (e.g., Hennig-Schmidt et al., 2011; Di Guida et al., 2019) or given to subjects in the role of patients (Ahlert et al., 2012). We follow the latter approach and have subjects in the role of patients in the lab to account for different patients. Kesternich et al. (2015) compare experimental conditions with subjects in the role of patients to conditions in which patient benefit is donated to a charity. They observe that decision makers provide higher patient benefits if the corresponding payoffs are donated to charity.

[5] In order to avoid any income effects, only one period was randomly chosen for payment.

[6] Thus, 58 participants were assigned the role of physicians. Personal characteristics of these 58 subjects are summarized in Table A2 in Appendix A. After the first two sessions, we conducted a power analysis using the means and standard deviations of the low and intermediate budget level with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007). The calculation showed that we needed at least 27 subjects in order to detect a normalized effect of $dz = 0.585$. The analysis was based on a two-sided Wilcoxon matched-pairs signed-rank test with a significance level of 5% and an assumed power of 80%.

[7] Statistical analysis was conducted with Stata 14 (StataCorp, 2015).

[8] See Table A5 in Appendix A for the regression results. While the effect of budget is robust, the tendency to give fewer services to patients with high marginal benefits depends on the experimental session.

[9] In addition, four of the 58 physicians decide selfishly in at least 90% of their decisions.

[10] A tolerance of one unit for *equal quantities* is necessary for an uneven sum of quantities provided. For some combinations of patient characteristics and the sum of quantities provided, a tolerance of one unit is necessary for *equal benefits*. For consistency, we apply the same tolerance to all cases in one category.

[11] Note that this is not caused by the same subjects changing from *equal benefits* to *equal quantities*.

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SUPPORTING INFORMATION

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Appendix

A. Supplementary material

Table A.1: Predictions for allocation principles regarding the distribution of resources between the two patient types

Combination of patient types	Patient 1 θ_1	Patient 1 q_1^*	Patient 2 θ_2	Patient 2 q_2^*	Predictions for: Selfishness ($q_1 = q_2 = 0$)	Equal health outcomes: equal benefits ($b_1 = b_2$)	Severity of illness: equal quantities ($q_1 = q_2$)	Capacity to benefit: efficiency ($q_1 < q_2$)
1	0.5	15	0.5	15	$q_1 = q_2 = 0$	$b_1 = b_2$	$q_1 = q_2$	-
2	1	15	1	15	$q_1 = q_2 = 0$	$b_1 = b_2$	$q_1 = q_2$	-
3	2	15	2	15	$q_1 = q_2 = 0$	$b_1 = b_2$	$q_1 = q_2$	-
4	0.5	15	1	15	$q_1 = q_2 = 0$	$q_1+q_2 \leq 23$: $b_1 = b_2$	$q_1 = q_2$	$q_1+q_2 < 30$: $q_1 < q_2$
						$23 < q_1+q_2 < 30$: $q_1 = q_1^*$		$q_1+q_2 = 30$: $q_1 = q_1^*$, $q_2 = q_2^*$
5	1	15	2	15	$q_1 = q_2 = 0$	$q_1+q_2 \leq 23$: $b_1 = b_2$	$q_1 = q_2$	$q_1+q_2 < 30$: $q_1 < q_2$
						$23 < q_1+q_2 < 30$: $q_1 = q_1^*$		$q_1+q_2 = 30$: $q_1 = q_1^*$, $q_2 = q_2^*$
6	0.5	15	2	15	$q_1 = q_2 = 0$	$q_1+q_2 \leq 19$: $b_1 = b_2$	$q_1 = q_2$	$q_1+q_2 < 30$: $q_1 < q_2$
						$19 < q_1+q_2 < 30$: $q_1 = q_1^*$		$q_1+q_2 = 30$: $q_1 = q_1^*$, $q_2 = q_2^*$
7	0.5	10	1	20	$q_1 = q_2 = 0$	$q_1+q_2 \leq 15$: $b_1 = b_2$	$q_1+q_2 \leq 20$: $q_1 = q_2$	$q_1 < q_2$
						$15 < q_1+q_2 < 30$: $q_1 = q_1^*$	$20 < q_1+q_2 < 30$: $q_1 = q_1^*$	
8	1	10	2	20	$q_1 = q_2 = 0$	$q_1+q_2 \leq 15$: $b_1 = b_2$	$q_1+q_2 \leq 20$: $q_1 = q_2$	$q_1 < q_2$
						$15 < q_1+q_2 < 30$: $q_1 = q_1^*$	$20 < q_1+q_2 < 30$: $q_1 = q_1^*$	
9	0.5	10	2	20	$q_1 = q_2 = 0$	$q_1+q_2 \leq 13$: $b_1 = b_2$	$q_1+q_2 \leq 20$: $q_1 = q_2$	$q_1 < q_2$
						$13 < q_1+q_2 < 30$: $q_1 = q_1^*$	$20 < q_1+q_2 < 30$: $q_1 = q_1^*$	
All					$q_1+q_2 \geq 0$; $q_1 \leq q_1^*$; $q_2 \leq q_2^*$			

Table A.2: Characteristics of subjects in the role of physicians

	Physicians (*N*=58)
Main characteristics	
Gender: share of females (%)	65.517
Share of medical students (%)	22.414
Age (Mean, sd)	22.672 (0.448)
Self-reported attitudes	
„Would you say that people usually… 1 …try to be helpful? 2 …only pursue their own interests?" (Mean, sd)	1.655 (0.063)
"Do you believe that most people… 1 …would use you if they had the chance? 2 …would try to be fair to you?" (Mean, sd)	1.397 (0.065)
"How would you place your views on this scale? 1 Incomes should be made more equal. - 10 There should be greater incentives for individual effort." (Mean, sd)	4.034 (0.279)
Social value orientation	
Angle (Mean, sd)	22.926 (1.743)
Type: prosocial (%)	55.172
individualistic (%)	44.828

Note: Summary statistics for characteristics of subjects in the role of physicians. In the questionnaire at the end of the experiment, subjects are asked about main characteristics and self-reported attitudes. The questions for self-reported attitudes are based on questions included in the European Values Study (European Values Study, 2020). The social value orientation results from the Social Value Orientation slider (Murphy et al., 2011) conducted in the second part of the experiment. According to the SVO slider, no subject is classified as altruistic or competitive.

Table A.3: Number of selfish decisions and optimally treated patients

	q_1=q_2=0 (N=1566)	q_j=q_j^* (N=3132)
all	219 (13.4%)	342 (10.9%)
budget=20	97 (18.6%)	12 (1.1%)
budget=30	70 (13.4%)	78 (7.5%)
budget=45	52 (10.0%)	252 (24.1%)
Null hypothesis	*p*-value	
budget: 20 = 30	0.082	<0.001
budget: 20 = 45	<0.001	<0.001
budget: 30 = 45	0.021	<0.001

Note: Number of selfish decisions and optimally treated patients by budget. Reported *p*-values are calculated with two-sided Wilcoxon matched-pairs signed rank tests using average values for subjects.

Table A.4: Medical service quantities provided by budget and marginal patient benefit

					Null hypothesis		
	all (N=3132)	θ_j=0.5 (N=1044)	θ_j=1 (N=1044)	θ_j=2 (N=1044)	θ_j: 0.5 = 1	θ_j: 0.5 = 2	θ_j: 1 = 2
all	5.77 (3.40)	6.01 (3.78)	6.17 (3.51)	5.12 (3.33)	0.637	0.001	<0.001
budget=20	3.54 (2.43)	3.89 (2.98)	3.64 (2.40)	3.07 (2.51)	0.187	0.002	0.001
budget=30	5.59 (3.47)	5.92 (4.10)	5.97 (3.74)	4.87 (3.24)	0.622	0.008	<0.001
budget=45	8.18 (4.66)	8.23 (4.83)	8.91 (4.87)	7.40 (4.71)	0.002	0.007	<0.001
Null hypothesis	*p*-value						
budget: 20 = 30	<0.001	<0.001	<0.001	<0.001			
budget: 20 = 45	<0.001	<0.001	<0.001	<0.001			
budget: 30 = 45	<0.001	<0.001	<0.001	<0.001			

Note: Number of service quantities provided by budget and marginal patient benefit. Mean quantities (sd) are calculated using subject averages. Reported *p*-values result from two-sided Wilcoxon matched-pairs signed rank tests.

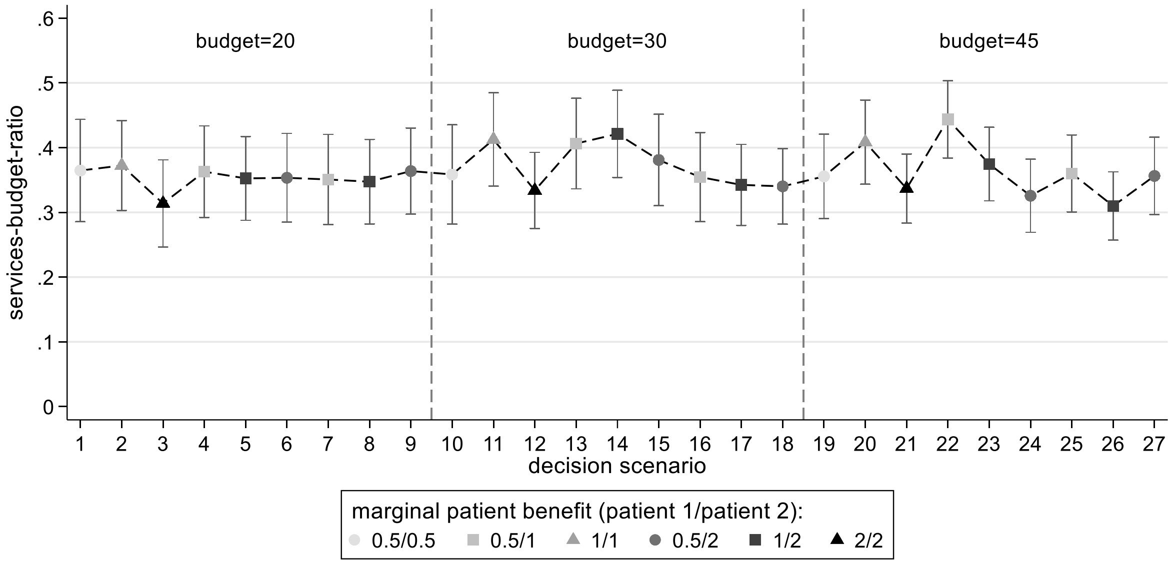
Table A.5: Influences on the medical service quantity provided

	Dependent variable: q_j				
	(1)	(2)	(3)	(4)	(5)
θ_j=0.5	-0.161	-0.146	-0.161	-0.470	-0.161
	(0.166)	(0.193)	(0.165)	(0.387)	(0.159)
θ_j=2	-1.055***	-1.022***	-1.055***	-0.282	-1.055***
	(0.158)	(0.184)	(0.155)	(0.386)	(0.148)
budget=20	-2.050***	-1.946***	-2.050***	-1.933***	-2.050***
	(0.138)	(0.163)	(0.137)	(0.324)	(0.134)
budget=45	2.593***	2.585***	2.593***	2.843***	2.593***
	(0.180)	(0.210)	(0.178)	(0.435)	(0.170)
θ_j=0.5×medical		-0.0680			
		(0.372)			
θ_j=2×medical		-0.144			
		(0.350)			
budget=20×medical		-0.465			
		(0.296)			
budget=45×medical		0.0345			
		(0.405)			
θ_j=0.5×session				0.0564	
				(0.0592)	
θ_j=2×session				-0.141**	
				(0.0583)	
budget=20×session				-0.0213	
				(0.0485)	
budget=45×session				-0.0457	
				(0.0659)	
svo_angle	0.162***	0.162***	0.162***	0.162***	0.177***
	(0.00559)	(0.00559)	(0.00560)	(0.00559)	(0.00556)
female	0.429***	0.429***	0.869***	0.869***	1.000***
	(0.140)	(0.141)	(0.156)	(0.156)	(0.149)
medical	0.826***	1.040***	1.529***	1.529***	1.009***
	(0.147)	(0.309)	(0.172)	(0.172)	(0.206)
session			-0.230***	-0.179***	
			(0.0307)	(0.0553)	
2.session					0.460
					(0.426)
3.session					-3.447***
					(0.257)
4.session					-2.958***
					(0.254)
5.session					-1.395***
					(0.272)
6.session					-1.733***
					(0.276)
7.session					-3.477***
					(0.283)
8.session					-1.755***
					(0.282)
9.session					-2.065***
					(0.337)
10.session					-2.341***
					(0.330)
Constant	1.802***	1.754***	2.623***	2.346***	2.946***
	(0.232)	(0.248)	(0.252)	(0.380)	(0.254)
Observations	3,132	3,132	3,132	3,132	3,132
Subjects	58	58	58	58	58
F-test	301.6	193.6	263.9	179.2	164.7
adjusted R^2	0.387	0.386	0.399	0.401	0.447

Note: Results from ordinary least-squares regressions with the quantity of medical services provided as dependent variable. As independent variables, we include dummy variables for the different values of marginal patient benefit and budget. We compare the different levels to the intermediate marginal benefit (θ_j=1) and budget (*budget*=30). In order to control for the social value orientation of subjects in the role of physicians, we include the SVO angle calculated based on subjects' decisions in the SVO slider (Murphy et al., 2011) in the second part of the experiment. We include dummy variables for female

subjects and medical students to account for personal characteristics. The variable session (models 3 and 4) indicates the number of the session (1-10) in which a subject participated. In model 5, we include dummy variables for sessions 2 to 10. In an additional regression model, we test interaction effects between the session dummies and the experimental parameters. We find some significant interaction effects but no consistent pattern. Robust standard errors are reported in parentheses.
****p*<0.01, ***p*<0.05, **p*<0.1.

Figure A.1: Average services-budget-ratio with 95% confidence intervals



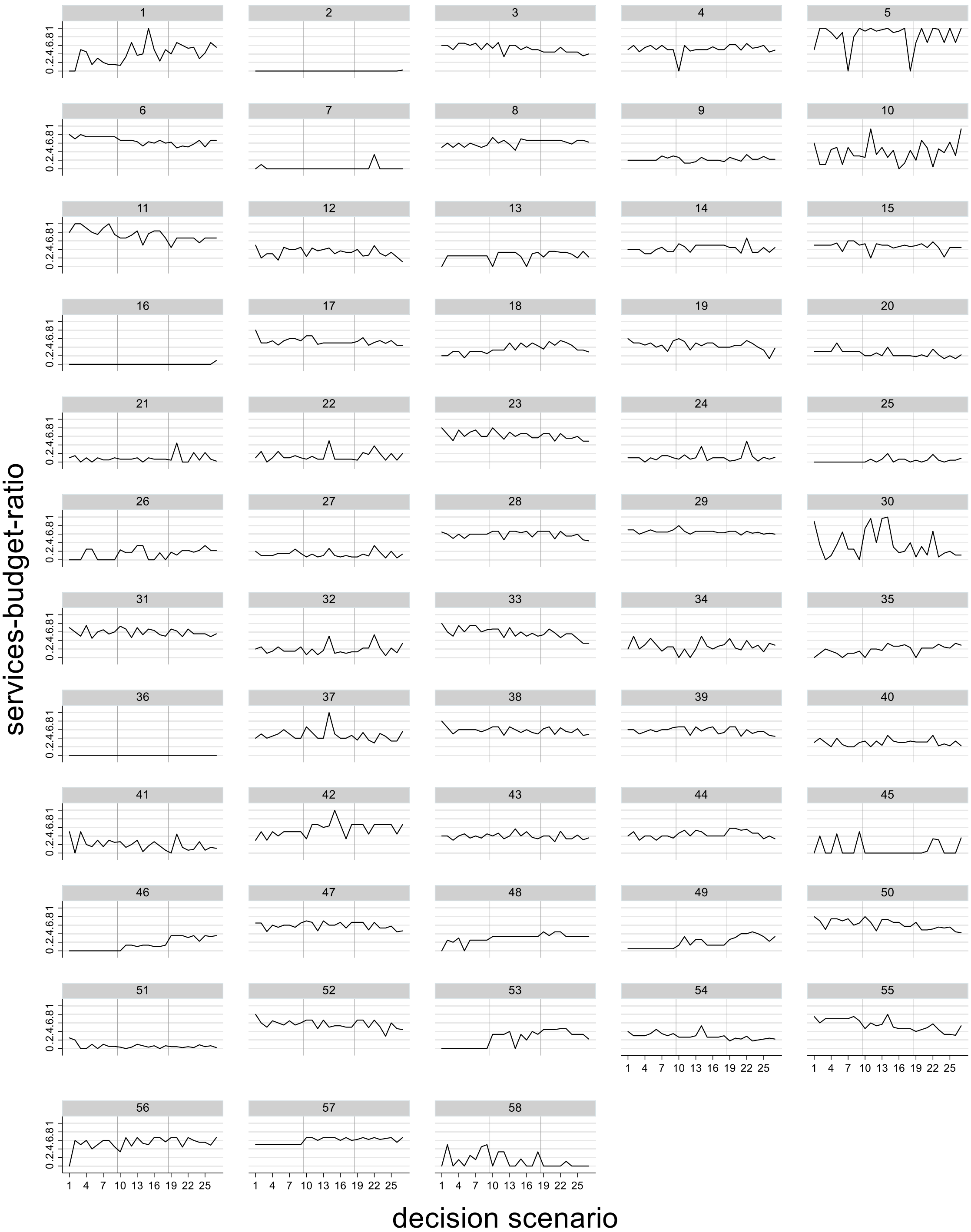
Note: This graph shows the average services-budget-ratio of the 58 subjects in the role of physicians in the 27 decision scenarios. The 27 decision scenarios are ordered by budget. The 95% confidence intervals are calculated for each decision scenario with the values of the 58 physicians based on a normal distribution.

Table A.6: Average services-budget-ratio by budget

	Services-budget-ratio $\gamma=(q_1+q_2)/budget$
all (*N*=1566)	0.363 (0.219)
budget=20 (*N*=522)	0.354 (0.243)
budget=30 (*N*=522)	0.372 (0.232)
budget=45 (*N*=522)	0.363 (0.207)
Null hypothesis	*p*-value
budget: 20 = 30	0.338
budget: 20 = 45	0.906
budget: 30 = 45	0.406

Note: Mean (sd) values for the services-budget-ratio by budget. Reported *p*-values are calculated with two-sided Wilcoxon matched-pairs signed rank tests using average values for subjects.

Figure A.2: Services-budget-ratios of the 58 physicians in the 27 decision scenarios



Note: This figure shows separate graphs with the services-budget-ratio for each subject in the role of physician. The 27 decision scenarios are ordered by budget: decision scenarios 1 to 9 (left to the first vertical line) comprise the nine combinations of patient types with budget=20, decision scenarios 10 to 18 (between the two vertical lines) comprise the nine combinations with budget=30, and decision scenarios 19 to 27 (right to the second vertical line) comprise the nine combinations with budget=45.

Table A.7: Average patient benefits as share of available budget

	all (*N*=3132)	θ_j=0.5 (*N*=1044)	θ_j=1 (*N*=1044)	θ_j=2 (*N*=1044)	Null hypothesis θ_j: 0.5 = 1	θ_j: 0.5 = 2	θ_j: 1 = 2
all	0.202 (0.123)	0.099 (0.062)	0.205 (0.115)	0.340 (0.221)	<0.001	<0.001	<0.001
budget=20	0.196 (0.139)	0.097 (0.074)	0.182 (0.120)	0.307 (0.251)	<0.001	<0.001	<0.001
budget=30	0.207 (0.128)	0.098 (0.068)	0.198 (0.122)	0.325 (0.216)	<0.001	<0.001	<0.001
budget=45	0.204 (0.118)	0.089 (0.051)	0.196 (0.105)	0.327 (0.207)	<0.001	<0.001	<0.001
Null hypothesis	*p*-value						
budget: 20 = 30	0.221	0.966	0.056	0.151			
budget: 20 = 45	0.535	0.188	0.159	0.148			
budget: 30 = 45	0.959	0.034	0.983	0.369			

Note: Benefits provided per unit of available budget. Mean (sd) values are calculated using subject averages. Reported *p*-values result from two-sided Wilcoxon matched-pairs signed rank tests.

B. Instructions of the experiment (translated from German)

B.1 Main experiment

Welcome to the experiment!

Preliminary remarks

You are participating in a study on decision-making in experimental economics research. During the experiment, participants will be asked to make decisions. By doing so, participants can earn money. How much money that will be depends on the decisions participants make. Please read the following instructions carefully. About 5 minutes after you have received the instructions, we will come by to answer any unresolved questions. In case you have further questions during the experiment, you can raise your hand or open the door at any time. We will then come to your cubicle and answer the question(s). All participants receive identical instructions.

The experiment consists of two parts. *Part 1* takes about 60 minutes and *part 2* about 10 minutes.

Part 1

In this part of the experiment, all amounts are shown in token, the experimental currency unit. At the end of the experiment, your earnings will be converted to Euro and paid out in cash.

Description of decision-making

In part 1 of the experiment, you will take part in 27 periods of decision-making. Some participants take the role of physicians, others the role of patients. At the beginning of the experiment, one of these roles is assigned to you randomly. The assigned role remains for all 27 periods. Each physician is matched with two patients. This matching will be retained for all 27 periods.

Subjects in the role of "physician"

In each period, subjects in the role of physician decide on the medical treatment for two patients; for each of the two patients, they determine a quantity of medical services. This quantity can differ between the two patients. For the physician, each unit of medical services results in a cost of 1 token.

In each period, physicians receive a capitation fee for each of the two patients for medical treatment. The sum of these capitation fees determines the budget of the physician. The budget can be spent on both patients irrespective of the individual capitation fee. The physician's profit is calculated by subtracting the units of medical services provided to the two patients from the physician's budget. A patient's benefit is determined by the quantity of medical services that the physician allocates to him. On your screen, you will see a table providing information about the patient benefit resulting from each possible quantity of medical services, the budget size, and the physician's profit. Please note that the physician's budget and the patient benefits vary between different periods. In some periods, both patients receive the same marginal patient benefit for each unit of medical services; in other rounds, their marginal patient benefit differs. However, the capitation fee never differs between the two patients.

Subjects in the role of "patient"

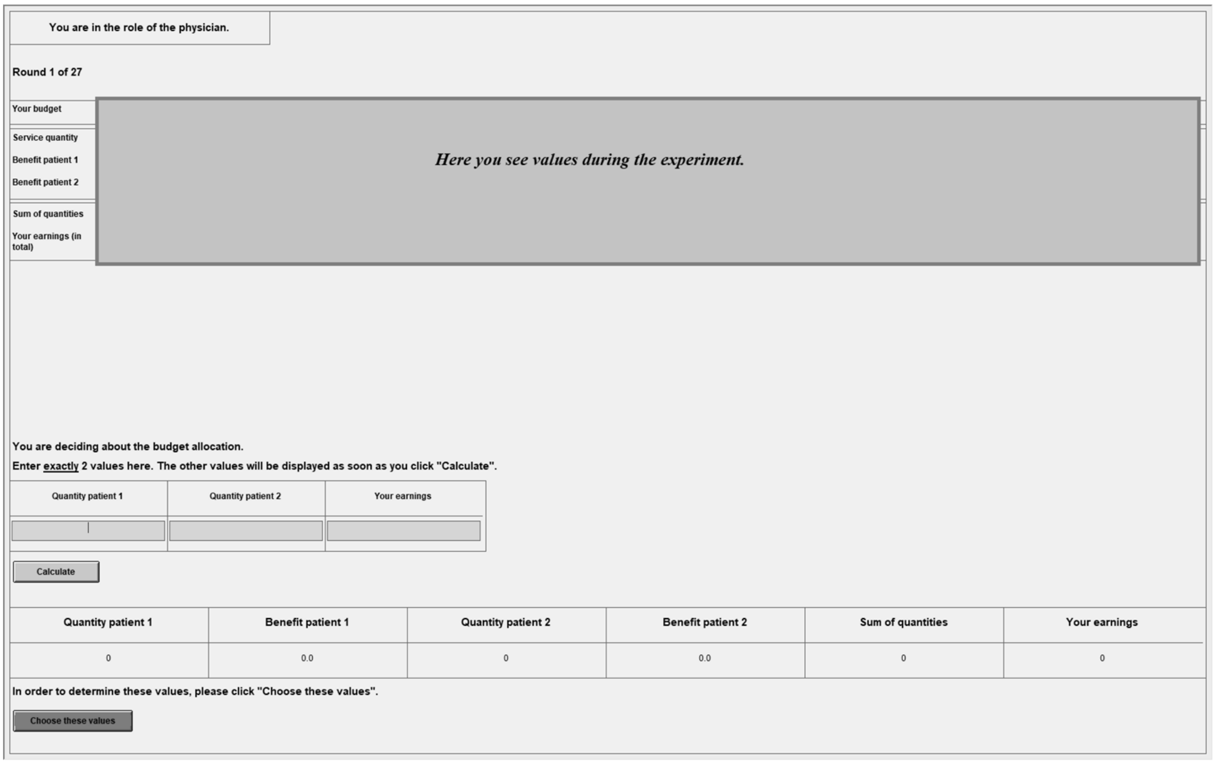
A patient's benefit is determined by the quantity of medical services provided by the physician. Once a patient has received his maximal benefit, additional units of medical services do not result in additional patient benefit.

Decision-making of physicians

In each period, subjects in the role of physician see a screen with the following information (see screenshot below):

- The size of the physician's budget
- Patient benefit for patient 1 (for each possible quantity of medical services)
- Patient benefit for patient 2 (for each possible quantity of medical services)
- The physician's profit (for each possible total quantity of medical services devoted to patient treatment)

The physician's decision consists of two steps. First, the physician has to enter two values into the light blue boxes. It is possible to enter different quantities of medical services for patient 1 and patient 2. It is also possible to enter only the quantity of medical services for one of the patients and, in addition, the physician's profit. As soon as the physician has entered two values and has clicked the button "calculate", all remaining values appear in a table at the bottom of the screen. In step two, after the physician has decided on an allocation of the budget, they have to confirm the values by clicking the button "Choose these values".



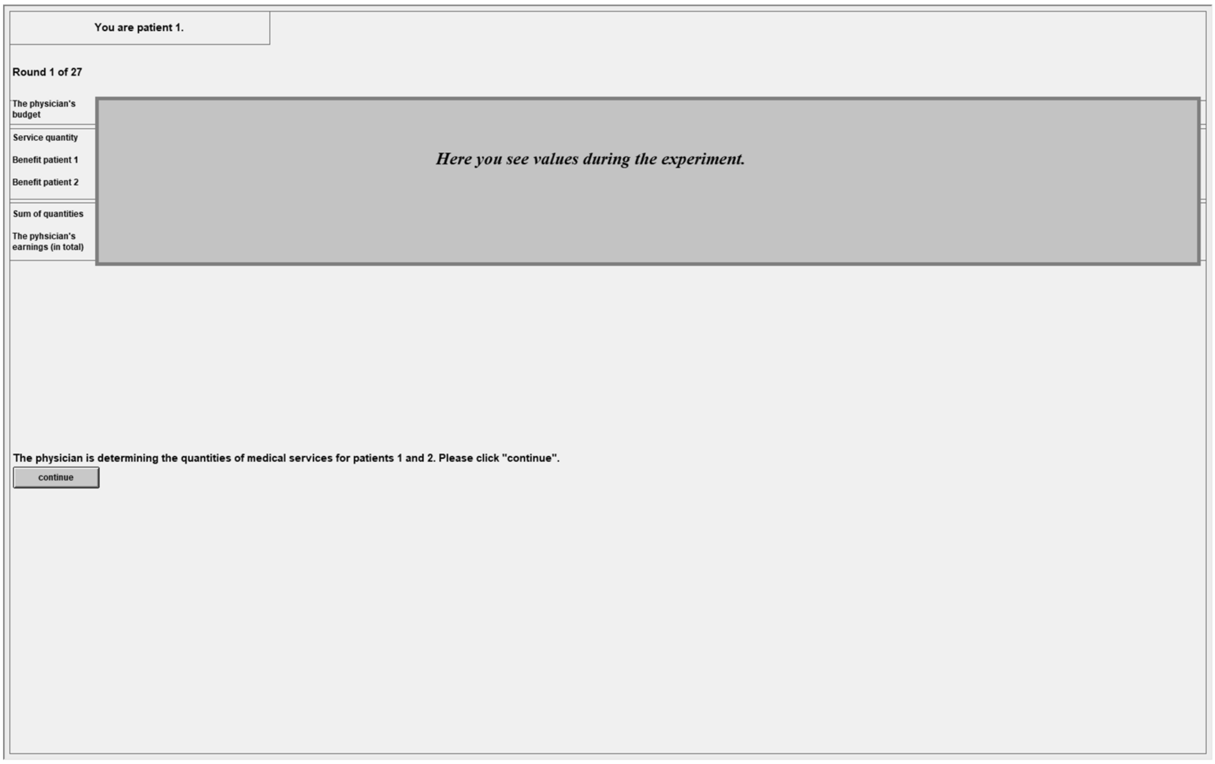
Screenshot: Subjects in the role of physician

<u>Patients</u>

Subjects in the role of patients do not take any decisions. However, similar to subjects in the role of physician, they see a screen with the following information in each period (see screenshot below):

- The size of the physician's budget
- Patient benefit for patient 1 (for each possible quantity of medical services)
- Patient benefit for patient 2 (for each possible quantity of medical services)
- The physician's profit (for each possible total quantity of medical services devoted to patient treatment)

During the 27 periods of decision-making, subjects in the role of patients do not find out about the actual allocation decisions of the physician.



Screenshot: Subjects in the role of patients

<u>Payment</u>

After finishing part 1, one of the 27 periods is randomly selected for payment. The payment of the physician is determined by their profit, the payment of patients by their patient benefit in this randomly selected period. Patients do not receive any information about the actual decisions of their physician throughout the entire experiment. Consequently, they only learn when being paid at the end which quantity of medical services the physician allocated to them in the period selected for payment. Physician profit and patient benefit are converted to Euro and are paid out in cash (1 token = 1 Euro).

Payment for part 1 takes place after part 2 of the experiment. Thus, you will not see the payment information described above until part 2 has ended.

<u>Comprehension questions</u>

Before the 27 periods of decision-making start, we ask you to answer a few comprehension questions. These comprehension questions are designed to familiarize you with the decision scenario. In case you have any questions, please open the door to your cubicle or raise your hand. The 27 periods of decision-making start after all participants have answered the comprehension questions.

Part 2

The instructions for part 2 of the experiment are displayed on your screen as soon as part 2 starts. In part 2 of the experiment, all amounts are shown in Euro. At the end of the experiment, your earnings from part 2 will be added to your payment from part 1. The sum will be paid in cash.

B.2 **Second part (on screen)**

In part 2, you will distribute certain amounts of money between yourself and another participant. We will refer to the other participant as “the other” in the following.

All your choices are completely confidential. For each of the following 6 questions, please indicate the distribution of money you prefer most.

There are no right or wrong answers, this is all about personal preferences.

After you have made your decision, mark the respective position. You can only mark one position per question. Your choices will influence the amount of money you receive as well as the amount of money the other receives. After you have marked the favored position, please click “OK” in order to get to the next question.

Payment

After finishing part 2, one decision is selected for payment for each participant. You receive the amount of money you have allocated to yourself in the decision which was chosen for you. Another participant in the lab receives the amount of money you have allocated to the other in this decision.

In addition, you receive the amount of money that another participant has allocated to the other in the decision which was chosen for them. This participant is not the same as the one who receives an amount of money from you.

In part 2, all amounts of money will be shown in Euro.

Chapter 4

Write something: An experiment on patient messages and physician provision behavior

Reference

Then, F. (2022). Write something: An experiment on patient messages and physician provision behavior. Unpublished working paper.

Write something: An experiment on patient messages and physician provision behavior

Franziska Then[a]

November 2022

Abstract

While experimental studies show that communication affects decision-making in various settings, evidence on how communication affects patients' medical treatment is scarce. In addition, distant forms of communication have become more important in health care in recent years. This study investigates if patients' opportunity to send text messages influences physician provision behavior in a lab experiment. Providing an opportunity to send a message does not affect medical service provision per se. When patients send an empty message, they receive significantly lower benefits though. Moreover, message content influences patient benefits depending on patient type: Requesting a specific benefit is detrimental for stronger patients, weaker patients benefit from increasing social proximity to a female physician.

JEL classifications: C91, D83, I11

Keywords: communication; physician behavior; laboratory experiment

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1 Introduction

Various experimental studies provide evidence that communication influences decisions and can, for example, increase trust (e.g., Buchan et al., 2006; Charness and Dufwenberg, 2006) or cooperation (e.g., Bochet et al., 2006; Brosig et al., 2003). Although communication is an important aspect in patient-physician-interaction and could also influence physicians' treatment decisions, evidence regarding effects on patients' health is scarce and mixed (Ong et al., 1995; Street et al., 2009). As online communication becomes more important in health care (e.g., Zanaboni and Wootton, 2016), particularly during the COVID-19 pandemic (e.g., Liu et al., 2020; Mann et al., 2020), the question if distant forms of communication like text messages influence medical care beyond diagnosis is especially relevant.

This study explores the link between patients' opportunity to send messages and physician provision behavior in a controlled lab experiment. While factors like patients' personalities or social support make it difficult to find direct effects of communication in the field, the controlled lab environment allows ceteris paribus variations of patients' characteristics and the opportunity to send a message. Since physicians usually treat several patients, patients compete to some extent for limited resources and could bargain for a higher share (see Bolton and Brosig-Koch, 2012, for the role of communication in bargaining). Therefore, this study examines communication effects in a setting which involves resource rivalry between two patients. In particular, the experiment of Brendel et al. (2021) is used as baseline and extended with patient messages. In the experiment, subjects in the role of physicians receive a budget which they can use to provide medical services to two other subjects who are in the role of patients. Facts for medical treatment are common knowledge. In the communication condition, patients have the opportunity to send free-form text messages to physicians which allows to study how different message contents influence physicians' decisions.

Patients' messages are not included in the payment functions and therefore do not directly affect physician profit or patient benefit. However, they may decrease the social distance between patients and physicians and, thus, lead to the provision of higher patient benefits (see, e.g., Charness and Gneezy, 2008; Rankin, 2006, for the role of communication on social distance). Experimental evidence supports this assumption. In dictator game experiments, messages from passive recipients regularly increase giving (e.g., Andreoni and Rao, 2011; Mohlin and

Johannesson, 2008; Rankin, 2006).[1] Moreover, studies with three-person settings indicate that, compared to a talking recipient, remaining silent is detrimental for recipients (Frey and Bohnet, 1997; Greiner et al., 2012). Charness and Rabin (2005) observe that remaining silent voluntarily may lead to even worse outcomes than when silence is mandated. In addition to the positive effect of messages itself, the specific content of messages seems to matter for decisions. Bruttel and Stolley (2020) show that dictators give more often when recipients put effort in writing a message, write in a humorous way, or refer to need. Also, messages referring to social proximity can affect the choice of transaction partners or physicians positively (Brosig-Koch et al., 2022; Brosig-Koch and Heinrich, 2018). On the other hand, Rankin (2006) highlights the possibility that communication – especially if it expresses some sort of entitlement – could also diminish the good feeling decision makers get from acting prosocially and therefore crowd out prosocial behavior. This is particularly possible for messages containing requests which may reflect the senders' expectations. In dictator game experiments, requests for specific amounts typically increase recipients' payoffs but decrease giving if they are too high (e.g., Kleine et al., 2016; Rankin, 2006; Yamamori et al., 2008).

The question of whether messages enhance prosocial behavior seems especially important for decisions related to health care. Although experiments have been applied to several aspects in health economics (see Galizzi and Wiesen, 2018, for an overview), only Brosig-Koch et al. (2022) also study communication effects in medical decision-making. In contrast to their experiment, patients send messages to physicians in this study. The experimental set-up is presented in the following section. Section 3 presents the behavioral hypotheses, section 4 summarizes the main findings, and section 5 concludes.

2 Experimental design and procedures

2.1 Design of the experiment

The between-subjects design extends the medically framed experiment of Brendel et al. (2021) with patient messages. The experiment of Brendel et al. (2021) is particularly suitable as baseline because of three reasons. First, physicians simultaneously allocate limited resources to two patients, accounting for a potential rivalry for resources between patients. Second, the payment structure for physicians is simple and thus lets them focus on patients' messages and

[1] Xiao and Houser (2009) and Langenbach (2016) show that dictators are even less selfish when recipients can send a message after the allocation decision.

the allocation decision. And third, the systematic variation of patient characteristics with one weaker and one stronger patient allows for a clear interpretation of results when physicians distinguish between patient types.

The baseline setting is as follows: Subjects are matched in groups of three (partner matching), with one subject in the role of a physician and two subjects in the role of patients.[2] The physician receives a budget in each of the 27 periods which they can use to provide medical service quantities q_j to the two patients in their group, $j = 1, 2$. The medical service quantities provided determine physician profit π and patient benefits b_j.

Patients receive their marginal health benefit $\theta_j \in \{0.5, 1, 2\}$ for each unit of medical services up to the optimal quantity $q_j^* \in \{10, 15, 20\}$. A quantity exceeding the optimum neither increases nor decreases patient benefit:

$$b_j(q_j) = \begin{cases} \theta_j q_j \text{ if } q_j < q_j^* \\ \theta_j q_j^* \text{ if } q_j \geq q_j^* \end{cases}.$$

Physicians are paid a capitation payment and receive a *budget* in each period. To keep the decision situation as simple as possible, physicians do not face convex but linear costs $c = 1$ for medical services (see also, e.g., Kesternich et al., 2015; Reif et al., 2020):

$$\pi(q_1,q_2) = budget - (q_1 + q_2).$$

For their focus on resource scarcity and allocation decisions, Brendel et al. (2021) include three levels of budget $\in \{20, 30, 45\}$ and systematically vary patient characteristics. Patients' marginal benefits and optimal quantities vary in nine combinations of patient types (see Table 1), allowing to distinguish between several allocation principles.[3] While both patients have the same characteristics in combinations one to three, different patient types are mixed in combinations four to nine with patient 2 having a higher marginal benefit than patient 1. Therefore, patient 1 is characterized as the weaker patient and patient 2 as the stronger patient. As previous experimental studies find considerable heterogeneity in allocation decisions between subjects (Brendel et al., 2021; Li et al., 2017) and the focus here is on the influence of

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[2] While patient benefit is donated to a charity in many health economic experiments (e.g., Brosig-Koch et al., 2016; Hennig-Schmidt et al., 2011), Brendel et al. (2021) have subjects in the role of patients in the lab to account for different patients (see also Ahlert et al., 2012). Of course, it is essential to have subjects in the role of patients when investigating patient messages.

[3] Besides selfishness the experimental design allows to distinguish between the three allocation principles based on medical need (e.g., Culyer and Wagstaff, 1993; Williams and Cookson, 2008): providing equal patient benefits, allocating services based on patients' initial level of illness (here: equal number of services), and allocating more services to the patient with a higher increase in benefit.

patient messages, the simple characterization of patient 1 as the weaker and patient 2 as the stronger patient is used in the analysis. The experiment is conducted once with each combination of patient types and each of the three budgets resulting in 27 periods.

Table 1: Patient characteristics in the nine combinations of patient types

Combination of patient types	Patient 1 θ_1	Patient 1 q_1^*	Patient 2 θ_2	Patient 2 q_2^*
1	0.5	15	0.5	15
2	1	15	1	15
3	2	15	2	15
4	0.5	15	1	15
5	1	15	2	15
6	0.5	15	2	15
7	0.5	10	1	20
8	1	10	2	20
9	0.5	10	2	20

In addition to the setting described above, patients can write a message to their physician prior to each allocation decision in the communication condition. Compared to other communication forms written messages maintain the highest possible control. To keep patients' opportunity to communicate still as open as possible, patients can write free-form text messages (as in, e.g., Andreoni and Rao, 2011; Bruttel and Stolley, 2020; Kleine et al., 2016). It is only not permitted to give personal details about oneself to rule out reputation effects from outside the lab. The opportunity to write freely is especially important because specific message contents can influence decision-making. In particular, messages referring to social proximity or requests typically affect decisions (e.g., Brosig-Koch et al., 2022; Brosig-Koch and Heinrich, 2018; Rankin, 2006; Yamamori et al., 2008). Note however, that patients are not required to write a message. If they do not write something, the physician sees a note saying that the patient sent an empty message. The opportunity to write a message thus represents a voluntary communication option for patients such as an optional text field in an anamnesis questionnaire.

2.2 Experimental procedures

The experiment was programmed with z-Tree (Fischbacher, 2007) and conducted at the Essen Laboratory for Experimental Economics between November 2016 and January 2017 as well as in December 2017. 315 participants from different fields of study were recruited with ORSEE (Greiner, 2015). Participants were recruited from a conventional subject pool because several experimental studies demonstrate that medical students, non-medical students, and physicians do not differ qualitatively in their behavioral responses to changes in the decision setting (e.g., Brosig-Koch et al., 2016, 2017; Hennig-Schmidt and Wiesen, 2014; Reif et al., 2020; Wang et al., 2020; for a short discussion see Galizzi and Wiesen, 2018). Due to groups of three, this resulted in 58 independent observations in the baseline and 47 independent observations in the communication condition.[4]

The order of the 27 periods was randomized and the same for all subjects in the baseline and the communication condition. Subjects were informed in the instructions that one period would be randomly chosen for payment (see Appendix B for the instructions). All amounts were given in tokens and exchanged to Euro at the end of the experiment (baseline: 1 token = 1 Euro, communication: 1 token = 1.50 Euro). As a control measurement for subjects' general social value orientation (SVO) subjects played the SVO slider (Murphy et al., 2011) in the second part of the experiment. Afterwards, subjects answered a non-incentivized questionnaire which contained questions on trust and inequality (based on questions in the European Values Study, 2020) and questions on demographics. The ten sessions of the baseline condition lasted 1.5 hours at most and subjects received 19.50 Euro on average. The eight communication sessions lasted about 2 hours and subjects received 25.39 Euro on average.

3 Behavioral hypotheses

While physicians have no information about patients in the baseline condition, they can learn something about patients from their messages in the communication condition. Patients' writing style, their choice of words, and the particular content of messages reduces their anonymity and thus the social distance to physicians. The greater social proximity may induce physicians to behave more prosocial (Bohnet and Frey, 1999; Charness and Gneezy, 2008; Rankin, 2006). This implies:

Hypothesis 1: *Patient benefits are on average higher in the communication condition than in the baseline condition.*

When patients do not write a message, they do not use the opportunity to increase social proximity. Moreover, physicians could reciprocate patients' reluctance to put effort in writing (Bruttel and Stolley, 2020). Thus, written messages should induce more prosocial behavior than empty messages:

[4] The experimental observations of Brendel et al. (2021) serve as the baseline condition for this study. See Table A.1 in Appendix A for personal characteristics of subjects in the role of physicians.

Hypothesis 2: *Patients in the communication condition receive higher benefits when they write a message than when they send an empty message.*

With respect to message content, messages which further increase social proximity should enhance the positive effect on physician provision behavior (Brosig-Koch et al., 2022; Brosig-Koch and Heinrich, 2018):

Hypothesis 3: *Patients in the communication condition receive higher benefits when they send a message that implies social proximity than when they send a message that does not imply social proximity.*

Following the argumentation by Rankin (2006), requests could express some sort of entitlement and therefore disrupt the positive effect of the communication opportunity:

Hypothesis 4: *Patients in the communication condition receive lower benefits when they request a specific benefit than when they send a message not containing a request.*

4 Results

4.1 Effects of patients' opportunity to send messages

To identify the pure effect of patients' opportunity to send messages, I investigate if physicians provide other patient treatment in the communication than in the baseline condition (hypothesis 1) and if patients actually send messages in the communication condition or not (hypothesis 2). On average, patients' health benefits in the baseline and in the communication condition do not differ significantly (patient 1: baseline=4.93, communication=4.11, p=0.122, two-sided Mann-Whitney U-test; patient 2: baseline=7.95, communication=7.03, p=0.285; see also Table A.2 in Appendix A). A closer look shows that physicians in the communication condition provide lower benefits to patients who send an empty message. While patient 1's benefit is 4.35 on average when writing a message, it is only 3.80 when sending an empty message (p=0.017, Wilcoxon matched-pairs signed rank test). Similarly, patient 2's benefit is 7.54 when writing a message but only 6.09 when sending an empty message (p=0.022). Thus, the results do not support hypothesis 1, even when comparing only benefits of patients who write a message to benefits of patients in the baseline condition ($p \geq 0.272$, two-sided Mann-Whitney U-test). Interestingly, physicians in the communication condition nevertheless respond to whether patients use the opportunity to communicate which is in line with hypothesis 2. Figure 1 illustrates patients' benefits in the baseline and the communication condition depending on writing a message.

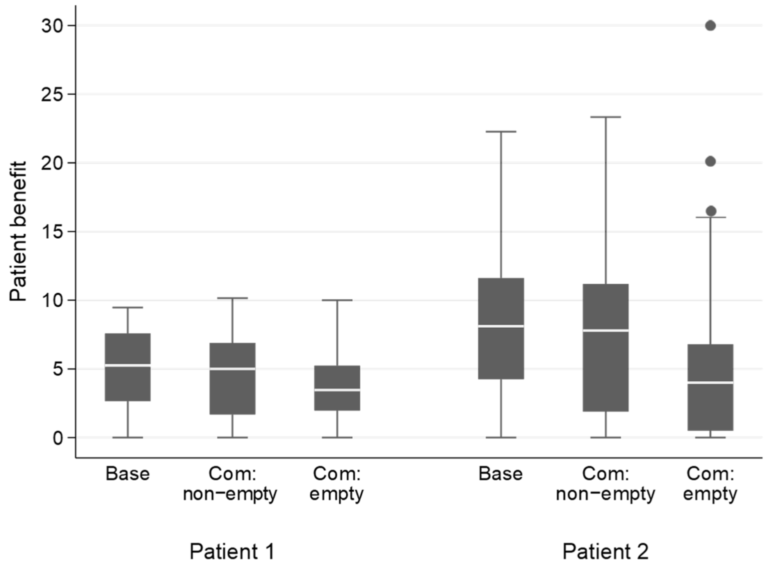

Figure 1: Boxplots for patient benefits in the baseline and in the communication condition (without or with empty messages)

As a robustness check, fractional response panel regressions[5] are conducted with the share of budget physicians devote to patient treatment, the services-budget-ratio, and patient 1's share of total benefit as dependent variables. The regressions contain control variables for period characteristics and for personal characteristics of physicians. In line with the non-parametric analysis, the results show that the opportunity to send a message does not affect physician provision behavior per se. Yet, it is detrimental for patients if they not use the opportunity (see Tables A.3 and A.4 in Appendix A).

4.2 Effects of message content

In order to analyze if physicians react to specific message contents, message content is classified. Based on hypotheses 3 and 4, the analysis focuses on the following categories:

- *Proximity*: This category identifies messages which imply a social proximity between patient and physician. This means they contain an emoticon (chat symbol or smiley) or the physician is informally addressed with the German second-person pronoun "Du".[6]

[5] Fractional response estimators fit models on continuous data between zero and one using, e.g., logit. As physicians decide in 27 periods in the experiment, the panel data method is applied (Papke and Wooldridge, 2008).

[6] Brosig-Koch and Heinrich (2018) and Brosig-Koch et al. (2022) use the same category in their classification.

- *Request*: This category identifies messages in which patients ask for a specific health benefit.

While empty messages were classified automatically, written messages were independently classified by two student assistants. Table 2 shows the classification results.

Table 2: Message classification

	Empty	*Proximity*	*Request*
Share of all messages	17.53%	26.08%	40.39%
(Krippendorff's Alpha)	(-)	(0.916)	(0.842)

Note: Share of messages that fall into a category. Krippendorff's Alpha is reported in parentheses. The reliability scores exceed the cutoff value of 0.70 (Krippendorff, 1980).

Effects of message content on physicians' decisions are analyzed using ordinary least-squares regressions with the benefit provided to patient 1 or 2 as dependent variables (see Table A.5 in Appendix A for the full results). Again, fractional response panel regressions serve as robustness check (see Tables A.6 and A.7 in Appendix A for the results).

The reaction to proximity messages depends strongly on the message recipient. While male physicians provide a lower benefit to the weaker patient (patient 1) if they send a proximity message (coef.: -1.905, s.e.:1.113), female physicians increase patient 1's benefit (interaction coef.: 2.375, s.e.:1.216) in line with hypothesis 3. The fractional response panel regressions confirm this observation.

Regarding requests, physicians provide a lower benefit to patient 2, the stronger patient, when they ask for a specific benefit (coef.: -0.762, s.e.: 0.432). Coherently, physicians reduce the services-budget-ratio based on requests from patient 2 (coef.: -0.0812, s.e.: 0.0372). Requests from patient 1 have no significant effect on patient benefit and on the services-budget-ratio. Although patient 1's requests seem to increase their share of total benefit (coef.: 0.111, s.e.: 0.0420), I am cautious drawing conclusions from this observation. Thus, the negative effect conjectured in hypothesis 4 only applies to requests from the stronger patient.

5 Conclusion

This study investigates how patients' opportunity to send messages influences physician provision behavior in a lab experiment. Physicians provide lower benefits to patients who do not write a message when having the opportunity. The observation that remaining silent voluntarily is particularly detrimental for patients is in line with hypothesis 2 (see also Charness and Rabin, 2005; Greiner et al., 2012). A possible explanation could be that physicians perceive that empty messages maintain a certain social distance between physicians and patients which could justify behaving less prosocially. Or they could reciprocate patients' reluctance to put effort in writing a message (see also Bruttel and Stolley, 2020). An analysis of message contents reveals that specific message contents influence treatment decisions depending on patient type. Weaker patients especially benefit from increasing social proximity to female physicians which is in line with hypothesis 3. In contrast to hypothesis 3, proximity messages from patients 1 to male physicians lead to lower benefits for them. The reason for this reaction is not apparent. For patient 2 requesting a benefit is detrimental. This indicates that physicians may have perceived requests from the stronger patient as some sort of entitlement leading to less prosocial behavior (hypothesis 4). For the weaker patient this is not the case.

In contrast to other experiments (e.g., Andreoni and Rao, 2011; Mohlin and Johannesson, 2008) and hypothesis 1, the sole opportunity to communicate does not increase giving in this study. Following the argument by Deck et al. (2013), one explanation for this observation could be that physicians already provide a relatively high level of patient benefits in the baseline condition which leaves not much room for communication to improve it. This does not seem very likely as physicians still devote a somewhat smaller share of budget to patient treatment when both patients write a message (31.6%) than in the baseline condition (36.3%). Another explanation could be that the medical context elicits a different response to communication than a neutral frame (see also Ahlert et al., 2012, for effects of a medical framing).

Physicians' negative reaction to empty messages is striking. It is best for patients to write something – no matter what. Of course, the lab experiment simplifies the decision situation of physicians and certainly does not capture the richness of typical physician-patient-communication. Nevertheless, the highly controlled experiment allows to identify pure effects of written messages by patients. For a more comprehensive understanding of how distant forms of communication affect physician behavior, further research would be useful. While previous studies find that physicians respond similar to changes in the decision setting as students (see section 2.2), it would be helpful to test if this also applies to a setting involving communication. Moreover, future studies could test how forms of two-sided communication like an open chat or video communication influence medical decision making.

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Write something: An experiment on patient messages and physician provision behavior

Franziska Then*

Appendix

A. Supplementary material

Table A.1: Characteristics of subjects in the role of physicians

	Baseline condition (*N*=58)	Communication condition (*N*=47)
Main characteristics		
Gender: share of females (%)	65.517	44.681
Share of medical students (%)	22.414	6.383
Age (Mean, sd)	22.672 (3.415)	26.447 (5.425)
Self-reported attitudes		
„Would you say that people usually… 1 …try to be helpful? 2 …only pursue their own interests?" (Mean, sd)	1.655 (0.479)	1.702 (0.462)
"Do you believe that most people… 1 …would use you if they had the chance? 2 …would try to be fair to you?" (Mean, sd)	1.397 (0.493)	1.404 (0.496)
"How would you place your views on this scale? 1 Incomes should be made more equal. - 10 There should be greater incentives for individual effort." (Mean, sd)	4.034 (2.127)	4.213 (2.226)
Social value orientation		
Angle (Mean, sd)	22.926 (13.275)	22.209 (13.695)
Type: prosocial (%)	55.172	51.064
individualistic (%)	44.828	46.809
competitive (%)	0	2.128

Note: Summary statistics for characteristics of subjects in the role of physicians. In the questionnaire at the end of the experiment, subjects are asked about main characteristics and self-reported attitudes. The questions for self-reported attitudes are based on questions included in the European Values Study (European Values Study, 2020). The social value orientation results from the Social Value Orientation slider (Murphy et al., 2011) conducted in the second part of the experiment. According to the SVO slider, no subject is classified as altruistic.

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Table A.2: Patient benefits

	Patient 1	Patient 2
Baseline	4.93 (2.80)	7.95 (5.05)
Communication		
all	4.11 (2.86)	7.03 (5.58)
non-empty	4.35 (3.04)	7.54 (6.02)
empty	3.80 (2.87)	6.09 (8.04)
Null hypothesis	*p*-value	
Baseline = Communication: all	0.122	0.285
Baseline = Communication: non-empty	0.272	0.474
Baseline = Communication: empty	0.164	0.021
Communication: non-empty = empty	0.017	0.022

Note: Patient benefits provided by patient type and condition. Mean benefits (sd) are calculated using subject averages. Reported *p*-values result from two-sided Mann-Whitney U-tests for comparisons between the baseline and the communication condition and from Wilcoxon matched-pairs signed rank tests for comparisons within the communication condition.

Table A.3: Regression results for the effect of patient messages on the services-budget-ratio

	$\gamma=(q_1+q_2)/budget$		
	all	all	communication
	(1)	(2)	(3)
communication	-0.180	-0.573	
	(0.174)	(0.381)	
$empty_1$		-0.375***	-0.365***
		(0.118)	(0.112)
$empty_2$		-0.271***	-0.264***
		(0.0570)	(0.0607)
$empty_1 \times empty_2$		0.143	0.171
		(0.322)	(0.321)
$\theta_1 = 0.5, \theta_2 = 0.5$	-0.172***	-0.158***	-0.133
	(0.0600)	(0.0583)	(0.107)
$\theta_1 = 0.5, \theta_2 = 1$	-0.106***	-0.0942***	-0.112*
	(0.0378)	(0.0345)	(0.0603)
$\theta_1 = 0.5, \theta_2 = 2$	-0.183***	-0.173***	-0.129*
	(0.0383)	(0.0390)	(0.0730)
$\theta_1 = 1, \theta_2 = 2$	-0.147***	-0.141***	-0.0820
	(0.0394)	(0.0408)	(0.0748)
$\theta_1 = 2, \theta_2 = 2$	-0.186***	-0.180***	0.0156
	(0.0620)	(0.0628)	(0.112)
budget = 20	-0.121***	-0.125***	-0.175***
	(0.0439)	(0.0435)	(0.0629)
budget = 45	-0.0150	-0.0224	0.00447
	(0.0384)	(0.0389)	(0.0597)
SVO angle	0.0490***	0.0484***	0.0493***
	(0.00785)	(0.00786)	(0.0117)
female	0.274	0.228	0.316
	(0.173)	(0.174)	(0.273)
medical	0.278	0.288	0.397
	(0.188)	(0.188)	(0.261)
Constant	-1.803***	-1.260**	-1.925***
	(0.321)	(0.529)	(0.442)
Observations	2,835	2,835	1,269
Number of id	105	105	47
Wald χ^2	112.5	186.5	106.7
Prob > χ^2	0	0	0

Note: Results from binomial logit regressions using a General Estimation Equation population-averaged model (fractional response) with services-budget-ratio as dependent variable. As independent variables, dummy variables for the communication condition and empty messages from patients 1 and 2, respectively, are included. Dummy variables for the different combinations of marginal patient benefits and dummy variables for physician budget serve as control for period characteristics. The different levels are compared to the intermediate marginal benefits (θ_1=1, θ_2=1) and budget (*budget*=30). The SVO angle, calculated based on subjects' decisions in the SVO slider (Murphy et al., 2011) in the second part of the experiment, controls for the social value orientation of subjects in the role of physicians. Also, dummy variables for female subjects and medical students account for personal characteristics. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.4: Regression results for the effect of patient messages on patient 1's share of total patient benefit

	$b_1/(b_1+b_2)$		
	all	all	communication
	(1)	(2)	(3)
communication	0.00605	0.0488	
	(0.0915)	(0.0802)	
$empty_1$		-0.396***	-0.389***
		(0.111)	(0.116)
$empty_2$		0.0960	0.0510
		(0.120)	(0.109)
$\theta_1 = 0.5, \theta_2 = 0.5$	-0.00185	0.00390	0.0746
	(0.0371)	(0.0367)	(0.0766)
$\theta_1 = 0.5, \theta_2 = 1$	-0.529***	-0.525***	-0.463***
	(0.0572)	(0.0568)	(0.104)
$\theta_1 = 0.5, \theta_2 = 2$	-0.940***	-0.939***	-0.796***
	(0.0742)	(0.0737)	(0.119)
$\theta_1 = 1, \theta_2 = 2$	-0.421***	-0.420***	-0.427***
	(0.0472)	(0.0473)	(0.0780)
$\theta_1 = 2, \theta_2 = 2$	0.0824*	0.0846*	0.0780
	(0.0456)	(0.0456)	(0.0876)
budget = 20	-0.00640	-0.00922	-0.0614
	(0.0367)	(0.0370)	(0.0736)
budget = 45	-0.157***	-0.159***	-0.216***
	(0.0285)	(0.0285)	(0.0518)
SVO angle	-0.00609*	-0.00581*	-0.0131*
	(0.00320)	(0.00306)	(0.00678)
female	0.108	0.120	0.0764
	(0.0851)	(0.0787)	(0.166)
medical	-0.106	-0.0962*	-0.318
	(0.0694)	(0.0576)	(0.199)
Constant	0.154	0.136	0.405*
	(0.103)	(0.0955)	(0.218)
Observations	2,272	2,272	925
Number of id	99	99	42
Wald χ^2	457.1	500.5	234.4
Prob > χ^2	0	0	0

Note: Results from binomial logit regressions using a General Estimation Equation population-averaged model (fractional response) with patient 1's share of total patient benefit as dependent variable. As independent variables, dummy variables for the communication condition and empty messages from patients 1 and 2, respectively, are included. Dummy variables for the different combinations of marginal patient benefits and dummy variables for physician budget serve as control for period characteristics. The different levels are compared to the intermediate marginal benefits (θ_1=1, θ_2=1) and budget (*budget*=30). The SVO angle, calculated based on subjects' decisions in the SVO slider (Murphy et al., 2011) in the second part of the experiment, controls for the social value orientation of subjects in the role of physicians. Also, dummy variables for female subjects and medical students account for personal characteristics. Observations with q_1=q_2=0 and observations with two empty messages are excluded. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.5: Regression results for the effect of message content on patient benefits

		b_1			b_2	
	(1)	(2)	(3)	(4)	(5)	(6)
$proximity_1$	-2.113**		-1.905*	1.104		0.979
	(1.034)		(1.113)	(1.379)		(1.399)
$proximity_2$	1.015		1.148	0.379		0.255
	(0.867)		(0.855)	(2.165)		(2.222)
$proximity_1 \times proximity_2$	-1.962		-2.389	0.150		0.488
	(1.557)		(1.584)	(2.694)		(2.748)
female×$proximity_1$	2.552**		2.375*	-2.720*		-2.689*
	(1.140)		(1.216)	(1.496)		(1.515)
female×$proximity_2$	-2.190*		-2.327**	-0.627		-0.620
	(1.131)		(1.124)	(2.327)		(2.378)
female×$proximity_1 \times proximity_2$	2.889*		3.305*	0.782		0.620
	(1.756)		(1.795)	(2.868)		(2.918)
female	-0.117	0.486	-0.0212	-0.0545	-0.842	0.334
	(1.064)	(0.901)	(1.044)	(1.500)	(1.753)	(1.556)
log($request_1$+1)		0.429	0.476		-0.286	-0.286
		(0.314)	(0.304)		(0.281)	(0.288)
log($request_2$+1)		0.208	0.197		-0.731*	-0.762*
		(0.245)	(0.245)		(0.431)	(0.432)
log($request_1$+1)×log($request_2$+1)		-0.0593	-0.0830		0.220	0.224
		(0.150)	(0.146)		(0.191)	(0.192)
$\theta_1 = 0.5, \theta_2 = 0.5$	-3.340***	-3.118***	-3.132***	-2.778***	-2.966***	-2.943***
	(0.388)	(0.307)	(0.336)	(0.616)	(0.670)	(0.698)
$\theta_1 = 0.5, \theta_2 = 1$	-3.248***	-3.035***	-2.993***	-0.619	-0.633	-0.718
	(0.371)	(0.294)	(0.335)	(0.466)	(0.492)	(0.516)
$\theta_1 = 0.5, \theta_2 = 2$	-3.630***	-3.323***	-3.386***	4.978***	4.968***	4.977***
	(0.437)	(0.364)	(0.376)	(1.317)	(1.299)	(1.317)
$\theta_1 = 1, \theta_2 = 2$	0.0671	0.101	0.130	5.891***	5.907***	5.902***
	(0.266)	(0.244)	(0.255)	(1.084)	(1.083)	(1.080)
$\theta_1 = 2, \theta_2 = 2$	5.864***	5.899***	5.846***	5.732***	5.935***	5.915***
	(0.867)	(0.913)	(0.904)	(0.733)	(0.754)	(0.751)
budget = 20	-1.956***	-1.861***	-1.905***	-3.429***	-3.546***	-3.531***
	(0.270)	(0.291)	(0.268)	(0.407)	(0.439)	(0.422)
budget = 45	2.001***	1.878***	1.832***	4.820***	4.896***	4.924***
	(0.316)	(0.317)	(0.307)	(0.662)	(0.701)	(0.718)
SVO angle	0.0522	0.0658*	0.0544	0.227***	0.215***	0.229***
	(0.0384)	(0.0354)	(0.0386)	(0.0700)	(0.0743)	(0.0708)
medical	-0.485	-0.260	-0.290	0.895	0.533	0.670
	(1.293)	(1.546)	(1.505)	(1.574)	(1.450)	(1.584)
Constant	5.412***	3.733***	4.574***	0.389	1.776	0.919
	(1.234)	(1.288)	(1.466)	(2.355)	(2.723)	(2.498)
Observations	643	643	643	643	643	643
Number of id	38	38	38	38	38	38
Wald χ^2	560.4	266	657.2	182.6	174.1	180.5
Prob > χ^2	0	0	0	0	0	0

Note: Results from ordinary least-squares regressions with the benefit provided to patient 1 or 2 as dependent variable. As independent variables, the variables $proximity_1$ and $proximity_2$ indicate if the message from the respective patient falls in the proximity category. Furthermore, variables indicating requests for a specific health benefit from patients 1 and 2, respectively, are included. I use the natural logarithm and normalize it to zero for no requests by adding 1 before taking the logarithm. Dummy variables for the different combinations of marginal patient benefits and dummy variables for physician budget serve as control for period characteristics. The different levels are compared to the intermediate marginal benefits (θ_1=1, θ_2=1) and budget (*budget*=30). The SVO angle, calculated based on subjects' decisions in the SVO slider (Murphy et al., 2011) in the second part of the experiment, controls for the social value orientation of subjects in the role of physicians. Also, dummy variables for female subjects and medical students account for personal characteristics. Observations with q_1=q_2=0 and observations with empty messages are excluded. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.6: Regression results for the effect of message content on the services-budget-ratio

	$\gamma=(q_1+q_2)/budget$			
	communication	communication	communication	communication
	(1)	(2)	(3)	(4)
proximity$_1$	0.115	-0.120		-0.101
	(0.0769)	(0.0935)		(0.0994)
proximity$_2$	0.140	0.284*		0.291*
	(0.0876)	(0.162)		(0.157)
proximity$_1$×*proximity*$_2$	-0.0980	-0.149		-0.181
	(0.132)	(0.247)		(0.228)
female×*proximity*$_1$		0.377**		0.345**
		(0.147)		(0.150)
female×*proximity*$_2$		-0.222		-0.249
		(0.190)		(0.188)
female×*proximity*$_1$×*proximity*$_2$		0.0511		0.105
		(0.289)		(0.273)
female	0.356	0.288	0.384	0.334
	(0.308)	(0.322)	(0.300)	(0.317)
log(*request*$_1$+1)			0.0487	0.0505
			(0.0458)	(0.0436)
log(*request*$_2$+1)			-0.0881**	-0.0812**
			(0.0394)	(0.0372)
log(*request*$_1$+1)×log(*request*$_2$+1)			0.0107	0.00890
			(0.0180)	(0.0167)
$\theta_1 = 0.5$, $\theta_2 = 0.5$	0.0206	0.00408	0.0193	0.00809
	(0.127)	(0.122)	(0.125)	(0.119)
$\theta_1 = 0.5$, $\theta_2 = 1$	-0.00863	-0.0110	0.00852	0.00942
	(0.0510)	(0.0482)	(0.0480)	(0.0447)
$\theta_1 = 0.5$, $\theta_2 = 2$	-0.104	-0.111*	-0.0776	-0.0774
	(0.0703)	(0.0673)	(0.0666)	(0.0630)
$\theta_1 = 1$, $\theta_2 = 2$	-0.0855	-0.0926	-0.0727	-0.0837
	(0.0638)	(0.0623)	(0.0631)	(0.0596)
$\theta_1 = 2$, $\theta_2 = 2$	-0.0268	-0.0407	-0.0109	-0.0239
	(0.100)	(0.0970)	(0.105)	(0.101)
budget = 20	-0.135*	-0.140*	-0.144*	-0.150*
	(0.0760)	(0.0776)	(0.0785)	(0.0800)
budget = 45	-0.00686	-0.00987	-0.0171	-0.0223
	(0.0603)	(0.0601)	(0.0580)	(0.0572)
SVO angle	0.0493***	0.0466***	0.0500***	0.0474***
	(0.0128)	(0.0130)	(0.0125)	(0.0129)
medical	0.222	0.190	0.254	0.190
	(0.305)	(0.284)	(0.316)	(0.282)
Constant	-2.030***	-1.905***	-1.985***	-1.943***
	(0.477)	(0.487)	(0.483)	(0.495)
Observations	856	856	856	856
Number of id	43	43	43	43
Wald χ^2	70.07	76.10	51.76	108.9
Prob > χ^2	7.80e-10	8.32e-10	1.48e-06	0

Note: Results from binomial logit regressions using a General Estimation Equation population-averaged model (fractional response) with services-budget-ratio as dependent variable. As independent variables, the variables $proximity_1$ and $proximity_2$ indicate if the message from the respective patient falls in the proximity category. Furthermore, variables indicating requests for a specific health benefit from patients 1 and 2, respectively, are included. I use the natural logarithm and normalize it to zero for no requests by adding 1 before taking the logarithm. Dummy variables for the different combinations of marginal patient benefits and dummy variables for physician budget serve as control for period characteristics. The different levels are compared to the intermediate marginal benefits (θ_1=1, θ_2=1) and budget (*budget*=30). The SVO angle, calculated based on subjects' decisions in the SVO slider (Murphy et al., 2011) in the second part of the experiment, controls for the social value orientation of subjects in the role of physicians. Also, dummy variables for female subjects and medical students account for personal characteristics. Observations with empty messages are excluded. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table A.7: Regression results for the effect of message content on patient 1's share of total patient benefit

	$b_1/(b_1+b_2)$			
	communication (1)	communication (2)	communication (3)	communication (4)
proximity$_1$	0.0492	-0.312***		-0.267**
	(0.106)	(0.100)		(0.114)
proximity$_2$	0.00375	0.0645		0.119
	(0.166)	(0.192)		(0.198)
proximity$_1$×*proximity*$_2$	0.0520	-0.140		-0.271
	(0.158)	(0.289)		(0.294)
female×*proximity*$_1$		0.553***		0.510***
		(0.160)		(0.171)
female×*proximity*$_2$		-0.0891		-0.136
		(0.315)		(0.316)
female×*proximity*$_1$×*proximity*$_2$		0.257		0.383
		(0.347)		(0.350)
female	0.120	-0.0959	0.116	-0.0865
	(0.153)	(0.173)	(0.157)	(0.195)
log(*request*$_1$+1)			0.108**	0.111***
			(0.0438)	(0.0420)
log(*request*$_2$+1)			0.0722	0.0776
			(0.0571)	(0.0566)
log(*request*$_1$+1)×log(*request*$_2$+1)			-0.0468**	-0.0502**
			(0.0233)	(0.0237)
$\theta_1 = 0.5, \theta_2 = 0.5$	0.0785	0.0736	0.0921	0.0922
	(0.0855)	(0.0870)	(0.0894)	(0.0887)
$\theta_1 = 0.5, \theta_2 = 1$	-0.439***	-0.432***	-0.410***	-0.401***
	(0.125)	(0.125)	(0.129)	(0.132)
$\theta_1 = 0.5, \theta_2 = 2$	-0.796***	-0.808***	-0.773***	-0.782***
	(0.138)	(0.140)	(0.138)	(0.138)
$\theta_1 = 1, \theta_2 = 2$	-0.463***	-0.466***	-0.454***	-0.462***
	(0.0704)	(0.0704)	(0.0704)	(0.0712)
$\theta_1 = 2, \theta_2 = 2$	-0.0388	-0.0448	-0.0638	-0.0699
	(0.113)	(0.114)	(0.120)	(0.121)
budget = 20	0.0106	0.00419	0.0171	0.00922
	(0.0706)	(0.0655)	(0.0694)	(0.0650)
budget = 45	-0.260***	-0.269***	-0.288***	-0.300***
	(0.0572)	(0.0577)	(0.0539)	(0.0550)
SVO angle	-0.0173***	-0.0201***	-0.0171***	-0.0201***
	(0.00578)	(0.00590)	(0.00603)	(0.00618)
medical	-0.438*	-0.489**	-0.356	-0.418*
	(0.266)	(0.218)	(0.305)	(0.236)
Constant	0.437**	0.653***	0.319	0.496**
	(0.175)	(0.188)	(0.203)	(0.233)
Observations	643	643	643	643
Number of id	38	38	38	38
Wald χ^2	195.9	340.2	262.4	385.5
Prob > χ^2	0	0	0	0

Note: Results from binomial logit regressions using a General Estimation Equation population-averaged model (fractional response) with patient 1's share of total patient benefit as dependent variable. As independent variables, the variables *proximity*$_1$ and *proximity*$_2$ indicate if the message from the respective patient falls in the proximity category. Furthermore, variables indicating requests for a specific health benefit from patients 1 and 2, respectively, are included. I use the natural logarithm and normalize it to zero for no requests by adding 1 before taking the logarithm. Dummy variables for the different combinations of marginal patient benefits and dummy variables for physician budget serve as control for period characteristics. The different levels are compared to the intermediate marginal benefits (θ_1=1, θ_2=1) and budget (*budget*=30). The SVO angle, calculated based on subjects' decisions in the SVO slider (Murphy et al., 2011) in the second part of the experiment, controls for the social value orientation of subjects in the role of physicians. Also, dummy variables for female subjects and medical students account for personal characteristics. Observations with q_1=q_2=0 and observations with empty messages are excluded. Robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

B. Instructions of the experiment (translated from German)

B.1 Main experiment

Welcome to the experiment!

Preliminary remarks

You are participating in a study on decision-making in experimental economics research. During the experiment, participants will be asked to make decisions. By doing so, participants can earn money. How much money that will be depends on the decisions participants make. Please read the following instructions carefully. About 5 minutes after you have received the instructions, we will come by to answer any unresolved questions. In case you have further questions during the experiment, you can raise your hand or open the door at any time. We will then come to your cubicle and answer the question(s). All participants receive identical instructions.

The experiment consists of two parts. *Part 1* takes about 60 minutes and *part 2* about 10 minutes.

Part 1

In this part of the experiment, all amounts are shown in token, the experimental currency unit, with 1 token = 1 Euro [**Communication:** 1 token = 1.50 Euro]. At the end of the experiment, your earnings will be converted to Euro and paid out in cash.

Description of decision-making

In part 1 of the experiment, you will take part in 27 periods of decision-making. Some participants take the role of physicians, others the role of patients. At the beginning of the experiment, one of these roles is assigned to you randomly. The assigned role remains for all 27 periods. Each physician is matched with two patients. This matching will be retained for all 27 periods.

Subjects in the role of "physician"

In each period, subjects in the role of physician decide on the medical treatment for two patients; for each of the two patients, they determine a quantity of medical services. This quantity can differ between the two patients. For the physician, each unit of medical services results in a cost of 1 token.

In each period, physicians receive a capitation fee for each of the two patients for medical treatment. The sum of these capitation fees determines the budget of the physician. The budget can be spent on both patients irrespective of the individual capitation fee. The physician's profit is calculated by subtracting the units of medical services provided to the two patients from the physician's budget. A patient's benefit is determined by the quantity of medical services that the physician allocates to him. On your screen, you will see a table providing information about the patient benefit resulting from each possible quantity of medical services, the budget size, and the physician's profit. Please note that the physician's budget and the patient benefits vary between different periods. In some periods, both patients receive the same marginal patient benefit for each unit of medical services; in other rounds their marginal patient benefit differs. However, the capitation fee never differs between the two patients.

Subjects in the role of "patient"

Aa patient's benefit is determined by the quantity of medical services provided by the physician. Once a patient has received his maximal benefit, additional units of medical services do not result in additional patient benefit.

[**Communication:**

Messages

Prior to the physician's decision-making, patients can send a message to the physician in each period. In principle, message content is up to the patients. It is however not permitted to give personal details like name, age, address, major, or profession. When deviating from these rules, the patient can be excluded from the experiment and does not receive any payment. Each message can contain up to 300 characters (about 2.5 lines). Click "Send" to send a written message.]

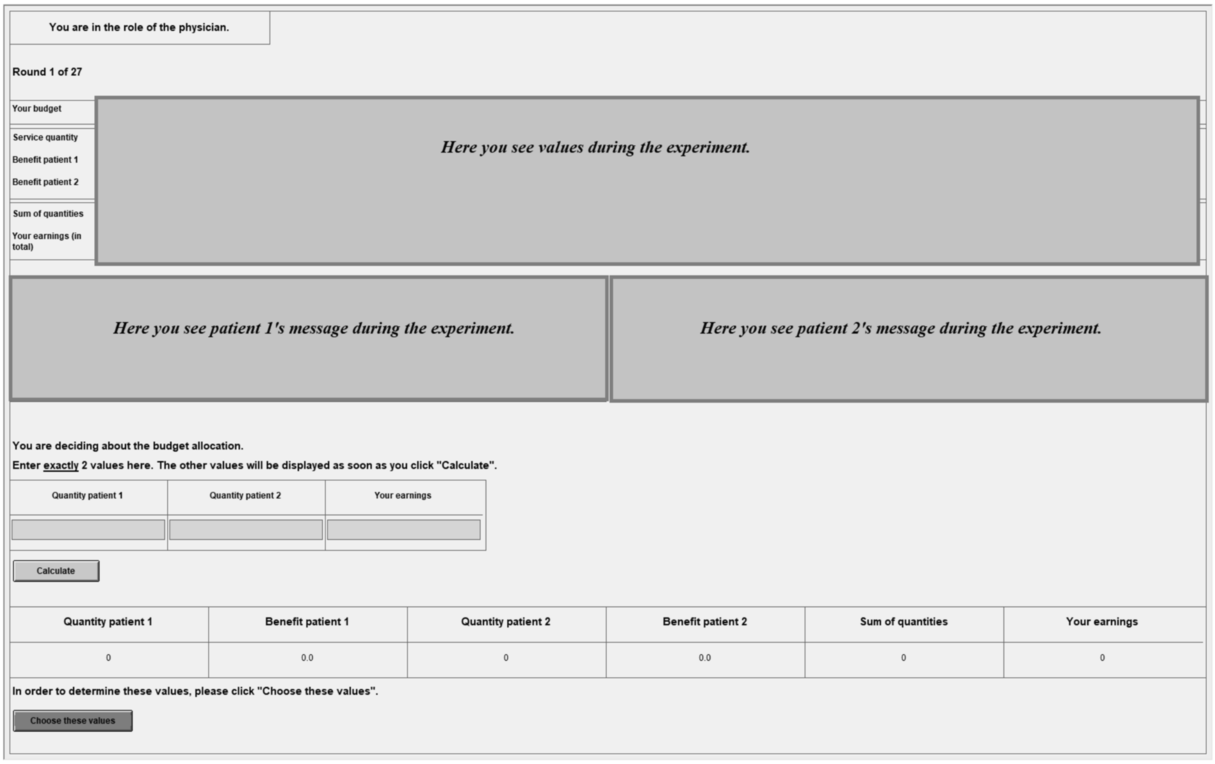
Decision-making of physicians

In each period, subjects in the role of physician see a screen with the following information (see screenshot below):

- The size of the physician's budget
- Patient benefit for patient 1 (for each possible quantity of medical services)
- Patient benefit for patient 2 (for each possible quantity of medical services)
- The physician's profit (for each possible total quantity of medical services devoted to patient treatment)

- [**Communication:** Patient 1’s message to the physician]
- [**Communication:** Patient 2’s message to the physician]

The physician’s decision consists of two steps. First, the physician has to enter two values into the light blue boxes. It is possible to enter different quantities of medical services for patient 1 and patient 2. It is also possible to enter only the quantity of medical services for one of the patients and, in addition, the physician’s profit. As soon as the physician has entered two values and has clicked the button “calculate”, all remaining values appear in a table at the bottom of the screen. In step two, after the physician has decided on an allocation of the budget, they have to confirm the values by clicking the button “Choose these values”.



Screenshot: Subjects in the role of physician

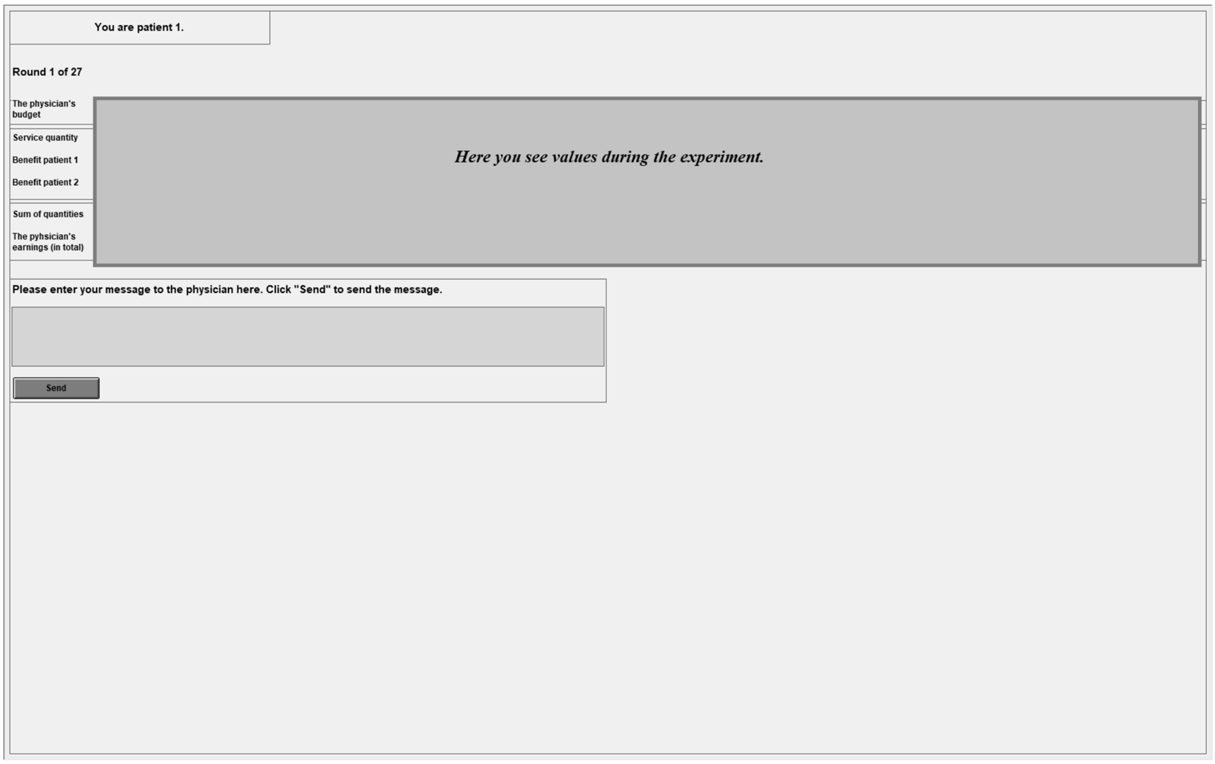
Patients

Subjects in the role of patients do not take any decisions. However, similar to subjects in the role of physician, they see a screen with the following information in each period (see screenshot below):

- The size of the physician’s budget
- Patient benefit for patient 1 (for each possible quantity of medical services)
- Patient benefit for patient 2 (for each possible quantity of medical services)

- The physician’s profit (for each possible total quantity of medical services devoted to patient treatment)
- [**Communication:** Their own message to the physician]

During the 27 periods of decision-making, subjects in the role of patients do not find out about the actual allocation decisions of the physician.



Screenshot: Subjects in the role of patients

<u>Payment</u>

After finishing part 1, one of the 27 periods is randomly selected for payment. The payment of the physician is determined by their profit, the payment of patients by their patient benefit in this randomly selected period. Patients do not receive any information about the actual decisions of their physician throughout the entire experiment. Consequently, they only learn when being paid at the end which quantity of medical services the physician allocated to them in the period selected for payment. Physician profit and patient benefit are converted to Euro and are paid out in cash (1 token = 1 Euro [**Communication:** 1 token = 1.50 Euro]).

Payment for part 1 takes place after part 2 of the experiment. Thus, you will not see the payment information described above until part 2 has ended.

Comprehension questions

Before the 27 periods of decision-making start, we ask you to answer a few comprehension questions. These comprehension questions are designed to familiarize you with the decision scenario. In case you have any questions, please open the door to your cubicle or raise your hand. The 27 periods of decision-making start after all participants have answered the comprehension questions.

Part 2

The instructions for part 2 of the experiment are displayed on your screen as soon as part 2 starts. In part 2 of the experiment, all amounts are shown in Euro. At the end of the experiment, your earnings from part 2 will be added to your payment from part 1. The sum will be paid in cash.

B.2 **Second part (on screen)**

In part 2, you will distribute certain amounts of money between yourself and another participant. We will refer to the other participant as "the other" in the following.

All your choices are completely confidential. For each of the following 6 questions, please indicate the distribution of money you prefer most.

There are no right or wrong answers, this is all about personal preferences.

After you have made your decision, mark the respective position. You can only mark one position per question. Your choices will influence the amount of money you receive as well as the amount of money the other receives. After you have marked the favored position, please click "OK" in order to get to the next question.

Payment

After finishing part 2, one decision is selected for payment for each participant. You receive the amount of money you have allocated to yourself in the decision which was chosen for you.

Another participant in the lab receives the amount of money you have allocated to the other in this decision.

In addition, you receive the amount of money that another participant has allocated to the other in the decision which was chosen for them. This participant is not the same as the one who receives an amount of money from you.

In part 2, all amounts of money will be shown in Euro.

Chapter 5

Rewards for information provision in patient referrals: a theoretical model and an experimental test

Reference

Brosig-Koch, J., Griebenow, M., Kifmann, M., & Then, F. (2022). Rewards for information provision in patient referrals: a theoretical model and an experimental test. *Journal of Health Economics*, *86*, 102677. https://doi.org/10.1016/j.jhealeco.2022.102677

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Rewards for information provision in patient referrals: A theoretical model and an experimental test☆

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ABSTRACT

We study whether bonus payments for information provision can improve the information flow between physicians. A primary care physician (PCP) decides on the provision of information of varying qualities to a specialist while referring a patient. Our theoretical model, which includes altruism and loss aversion, predicts that bonus payments increase the provision of both high- and low-quality information. Running a controlled laboratory experiment we find support for this prediction. If the beneficiary of information provision receives a higher payoff than the PCP, we observe that PCPs more often pass on high-quality information when the beneficiary is a patient. If the beneficiary receives a lower payoff than the PCP, the type of the beneficiary (specialist or patient) does not affect the provision of high-quality information.

1. Introduction

When patients are referred from one physician to another, the provision of information by the referring physician is important for the optimal care of the patient. The referring physician has already made an assessment of the patient's health and this information can help to treat the patient faster or to reduce the costs of the receiving physician. For example, the referring physician may know the patient's relevant medical history, which is useful in diagnosing the patient more accurately and making faster treatment decisions.

The information flow between physicians, however, does not seem to be optimal. In a literature review, Mehrotra et al. (2011) find that many referrals do not include a transfer of information and when they do, the data is often insufficient for medical decision making (see also Bodenheimer, 2008). As a potential solution to this problem, Bodenheimer (2008) proposes that care coordination tasks should be financially rewarded. For example, Medicare has started paying physicians for care coordination services of chronically ill patients in 2015 (Centers for Medicare & Medicaid Services, 2014).

In this paper, we present a model that considers both whether information is provided and, if information is provided, the quality of information. Information may be of low or high quality. High-quality information corresponds to a clear and complete

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0167-6296/

report about the patient's medical history and diagnostic results. Low-quality information corresponds to unclear or incomplete information. Usually, it is prohibitively costly for the payment authority in charge of remunerating health care services (the payer) to verify the quality of information provided by the physicians. Therefore, agency problems exist as the quality of information is private information of the physicians. Our model allows physicians to be partially altruistic towards their patients and fellow physicians. We further consider that some patients may benefit more from information provision than others. For example, for some patients treatment may be more urgent than for others and the information provided may speed up the treatment process.

We consider a bonus payment for information provision as a remedy for the under-provision of information. According to our model, the payment required to maximize the amount of provided high-quality information is a fraction of the costs of information provision. Increasing payments beyond this threshold only leads to the provision of more low-quality information. Finally, increasing the payment beyond the costs for low-quality information does not additionally change physician behavior.

In addition to the standard approach, we also include a non-linear version of our model that uses an S-shaped value function in the physician's utility function. This version is inspired by previous behavioral research suggesting that individuals evaluate monetary losses and gains from a reference point differently (see, e.g., Kuehberger, 1998; Bleichrodt et al., 2001; Abdellaoui et al., 2007). Although prospect theory has been initially suggested for risky contexts to explain such reference-dependent preferences (Kahneman and Tversky, 1979), Tversky and Kahneman (1991) apply its properties also to riskless decisions like those in our experiment (see, e.g., Gaechter et al., 2010, for experimental evidence). Here, physicians may also decide depending on a reference point because they can be faced with a decision between a monetary gain (providing low-quality information) and a monetary loss (providing high-quality information) for some levels of bonus payments. In contrast to the linear version, our non-linear model suggests that the amount of high-quality information provision can decrease with an increase in the payment for information provision. Furthermore, if the payments are increased beyond the costs of high-quality information provision, the effect reverses and more high-quality information is provided. This latter effect is caused primarily by loss aversion.

We test the theoretical predictions derived from our two models in a laboratory experiment. Using a controlled lab environment that allows ceteris paribus variations of bonus payments and benefits from information provision, we are able to establish the causal link between payments and the provision of information (for a general discussion of the experimental method see, e.g., Frechette and Schotter, 2015, and for a discussion of health economics experiments see Galizzi and Wiesen, 2018).[1] In our experiment, subjects in the role of primary care physicians (PCPs) decide on passing on information to subjects in the role of specialists while referring a patient. In all experimental conditions, we use a within-subject design and systematically vary the bonus payment as well as the benefit from information provision at the subject level to test the influence of both parameters. In our baseline condition, we focus on a situation in which the patient benefits from information provision and in which the PCP always earns less money than the specialist. The latter is typically the case in most OECD countries (OECD, 2015). Note that in this baseline condition bonus payments for information provision are implemented in addition to a fixed capitation payment. This additional payment may not be cost-effective from the payer's perspective, though. Accordingly, we implement a second experimental condition to test the behavioral effects of a cost-neutral version of the bonus payments.

With our remaining three experimental conditions we check the robustness of our behavioral results. First, we change the beneficiary of information provision (specialist instead of patient). Second, we alter the payoff relation between the PCP and the beneficiary. While the PCP always earns less than the beneficiary from information provision in the previous three conditions, we implement two additional conditions in which the PCP always earns more than the beneficiary (patient or specialist). Note that, without additional assumptions, the predictions derived from our two models do not imply a behavioral impact of these changes (cost neutrality, beneficiary, and payoff relation). Still, there is behavioral evidence suggesting such an impact (see the finding by Kesternich et al., 2015, on the role of the receiver type in medically framed distribution and cost dispersion games or the research on inequality aversion by, e.g., Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000).

As predicted by our model, PCPs in the experiment pass on more low- and high-quality information as the bonus payment increases. If the bonus payment is at least as high as the costs for the provision of high-quality information, PCPs provide less low-quality information and more high-quality information than in decision tasks with lower bonus payments. This behavioral pattern is in line with the non-linear version of our model considering an aversion to lose profit relative to a reference profit in addition to altruism. Moreover, we observe that PCPs' reactions to increases in the bonus payment are similar regardless of whether the bonus payment is introduced cost-neutrally or not. Accordingly, taking the perspective of a payer who trades off the benefit of information provision against his payments, we find that bonus payments exceeding the cost of low-quality information are only efficient if the bonus payment is introduced cost neutrally.

Checking the robustness of our results with regard to the type of the receiver and the payoff relation between the PCP and the beneficiary, we find similar behavioral responses to the bonus payment and the benefit of information provision across all conditions. Still, PCPs tend to make more selfish decisions and provide less high-quality information when two conditions are met — first, the specialist instead of the patient benefits from information provision and second, the PCP earns less than the specialist.

In sum, our study is the first to provide a model that allows to describe the effect of different bonus payments on information provision between physicians. In addition, using the controlled environment of a laboratory, we are able to test the predictions

[1] For a first laboratory experiment on patient referrals see Waibel and Wiesen (2021). Waibel and Wiesen (2021) do not focus on the provision of information in patient referrals, though.

Table 1
Benefits or savings and costs of information provision.

	0	l	h
b or s	0	$\kappa/3$	κ
c	0	$\mu/2$	μ

of this model and to check the robustness of results. Our findings contribute to the understanding of the conditions under which information provision between physicians can be effective.

2. A model for physician information provision

2.1. Benefits and costs of information provision

Two physicians, a primary care physician (PCP, "he") and a specialist ("she"), are tasked by a health care payment authority (payer) with the treatment of a patient. The PCP has determined that he is unable to help the patient and, therefore, refers the patient to the specialist for receiving treatment. In order to ease the transition process, the PCP can provide information on the patient's medical history and the result of his diagnostic testing to the specialist. He can pass on no information ($I = 0$), information of low quality ($I = l$), or information of high quality ($I = h$). The benefits from information provision may accrue to the patient (extra benefit b) or to the specialist (cost savings s). Specifically, the patient receives benefit $B = \bar{b} + b$ including a base benefit of $\bar{b}$ and the specialist accrues costs of $c_S = \bar{c}_S - s$ with maximum costs $\bar{c}_S$ from specialist treatment. In the former case, the patient can experience a better diagnosis and treatment procedure which increases her benefit. For example, the patient may not have to reproduce her medical history and therefore may save time. In the latter case, the specialist can provide the same diagnosis and treatment as without the PCP's information but at lower costs. For example, the specialist may not have to repeat diagnostic procedures.

To what extent information provision yields a benefit is likely to differ between cases. For example, in some cases fast treatment is necessary and information provision speeds up the treatment process. Also, diagnostic procedures can differ in time and costs. Furthermore, the benefit of the information depends on its quality. A carefully worded, compact, and complete report of all the relevant information is of greater use to the treating specialist but consumes more of the PCP's time and effort. The benefit from high-quality information provision is measured by $\kappa \geq 0$. If low quality is provided, we assume that the benefit is reduced to one third, i.e., to $\kappa/3$. The cost of information is the same for all patients and corresponds to μ in case of high-quality information and $\mu/2$ in case of low-quality information (see Table 1). These assumptions ensure that the provision of high-quality information is more cost-efficient than low-quality information provision. This reflects the empirical finding that information quality is often insufficient for medical decision making (Mehrotra et al., 2011).

Based on this general setting, we derive propositions for physician behavior in the following subsections. We consider a linear utility function for the PCP in Section 2.2. For an alternative version of the model, we take aversion to losses from a reference profit into account and allow for a non-linear utility function in Section 2.3.

2.2. Provider behavior — linear PCP utility

We first formulate a simple, linear model about physician behavior based on the standard model of altruistic physicians (Ellis and McGuire, 1986) and the assumption that the degree of altruism does not depend on the beneficiary of information provision. The PCP considers the benefit κ in the decision to provide information $I \in \{0, l, h\}$ with the altruism factor $\beta \geq 0$.

A PCP receives a capitation payment F_{PCP} upon seeing a patient. On top, a bonus payment γ is made to the PCP if he sends information. That is, overall payment for the PCP is

$$p(I) := \begin{cases} F_{PCP}, & I = 0 \\ F_{PCP} + \gamma, & I \neq 0. \end{cases} \tag{1}$$

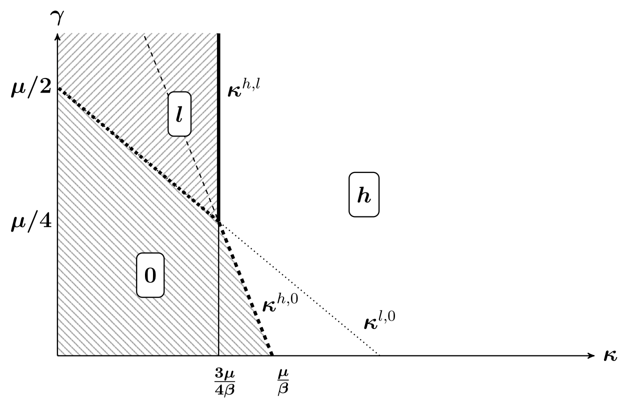
Capitations are set to ensure that the physicians' costs are always covered. We assume that the quality of information is not verifiable. Therefore, the PCP receives the bonus payment regardless of provided quality. If the patient benefits from information provision, the PCP's utility is given by

$$U(I) = p(I) - c(I) + \beta b(I). \tag{2}$$

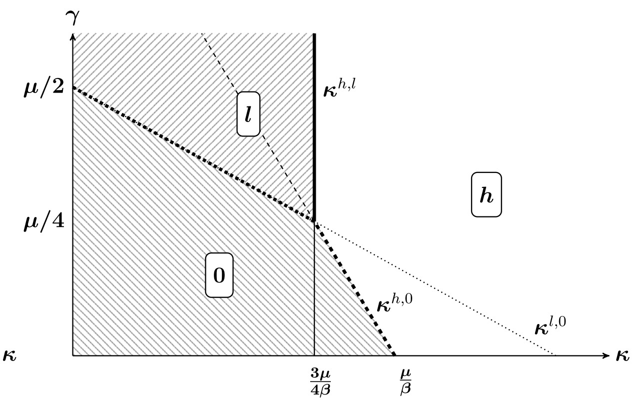
If the specialist benefits from information provision, we have

$$U(I) = p(I) - c(I) + \beta s(I). \tag{3}$$

Lemma 1 provides behavioral predictions for the PCP.



(a) Large β



(b) Small β

Fig. 1. Information provided by the PCP given payment γ and patient type κ, fixed β.

Lemma 1. *Let $\beta = 0$. PCP information provision is given by*

$$I^* = \begin{cases} 0, & \text{if } \gamma \leq \mu/2 \\ l, & \text{if } \gamma \geq \mu/2 \end{cases}$$

If $\beta > 0$:

$$I^* = \begin{cases} 0, & \text{if } \kappa \leq \min\left(\kappa^{l,0}, \kappa^{h,0}\right) \\ l, & \text{if } \kappa^{h,l} \geq \kappa \geq \kappa^{l,0} \\ h, & \text{if } \kappa \geq \max\left(\kappa^{h,l}, \kappa^{h,0}\right) \end{cases}$$

where $\kappa^{l,0} = \dfrac{3(\mu/2-\gamma)}{\beta}$, $\kappa^{h,0} = \dfrac{\mu-\gamma}{\beta}$ *and* $\kappa^{h,l} = \dfrac{3\mu}{4\beta}$.

Proof. If $\beta > 0$:

$$U(h) = F_{PCP} + \beta\kappa - \mu + \gamma \geq F_{PCP} + \beta\kappa/3 - \mu/2 + \gamma = U(l) \iff \kappa \geq \frac{3\mu}{4\beta}$$

$$U(h) = F_{PCP} + \beta\kappa - \mu + \gamma \geq F_{PCP} = U(0) \iff \kappa \geq \frac{\mu-\gamma}{\beta}$$

$$U(l) = F_{PCP} + \beta\kappa/3 - \mu/2 + \gamma \geq F_{PCP} = U(0) \iff \kappa \geq \frac{3(\mu/2-\gamma)}{\beta}$$

If $\beta = 0$:

$$U(h) = -\mu \leq -\mu/2 = U(l)$$

$$U(h) = -\mu + \gamma \geq 0 = U(0) \iff \gamma \geq \mu$$

$$U(l) = -\mu/2 + \gamma \geq 0 = U(0) \iff \gamma \geq \mu/2$$

□

If the PCP is egoistic ($\beta = 0$), he will never provide high-quality information as this is not rewarded. The PCP then only considers whether the payment exceeds the cost of providing information of low quality ($\mu/2$). He will not provide information if $\gamma < \mu/2$, provide low-quality information if $\gamma > \mu/2$, and be indifferent between these two options if $\gamma = \mu/2$. In contrast, if the PCP is partially altruistic, i.e. $\beta > 0$, the PCP will provide high-quality information if the value of information κ is high enough and provide low-quality information for intermediate values.

Lemma 1 states the values of κ^{I_1,I_2}, with $I_1, I_2 \in \{0, l, h\}$, for which PCPs are indifferent between I_1 and I_2. These are displayed in Figs. 1(a) and 1(b) which show how partially altruistic PCPs provide information depending on the value of information κ and the payment γ for large and small β respectively. For cases with a high benefit from information provision ($\kappa \geq \kappa^{h,l}$), the PCP prefers high-quality to low-quality information provision, for cases with small benefit ($\kappa \leq \kappa^{h,l}$), the opposite is true. This critical $\kappa^{h,l}$ is independent of the payment γ since the PCP receives the payment for either information quality. For $\kappa \geq \kappa^{h,l}$, the physician will either provide high quality or no information depending on whether $\kappa \gtreqless \kappa^{h,0}$. $\kappa^{h,0}$ is falling in γ, indicating that the physician is trading off providing high-quality information with monetary rewards. Thus, a larger payment γ can induce the physician to provide high-quality information. For $\kappa < \kappa^{h,l}$, the physician will either provide low-quality or no information depending on whether $\kappa \gtrless \kappa^{l,0}$. $\kappa^{l,0}$ is also falling in γ. Again, a larger payment γ can induce information provision, but only of low quality.[2]

The difference between Figs. 1(a) and 1(b) is the level of physician altruism β. Decreasing altruism shifts all κ boundaries to the right. Thus, a less altruistic PCP will provide less information and worse information quality for some patient types κ that would have received (high-quality) information from a PCP with stronger altruism.

Overall, three areas of information provision emerge. The thick parts of the lines indicate the boundaries between these areas. The payment values $\gamma = \mu/4$ and $\gamma = \mu/2$ are crucial. For $\gamma < \mu/4$, the PCP never provides low-quality information. With such low level of payment, altruism becomes the driving force for information provision, calling for high-quality information if κ is sufficiently high. Increasing γ beyond $\mu/4$ makes the provision of low-quality information interesting for PCPs for low values of κ. Increasing γ beyond $\mu/4$ up to $\gamma = \mu/2$ increases only the amount of low-quality information and has no effect on high-quality information. For a bonus payment $\gamma \geq \mu/2$, information will always be provided simply because the payment covers the cost of low-quality information provision.

Proposition 1 (proof in Appendix A.1) summarizes behavioral predictions for partially altruistic physicians that can be inferred from Lemma 1.

Proposition 1.

Let $\beta > 0$.

- *(a) For $\gamma \leq \mu/4$, only no or high-quality information will be provided. For $\gamma = 0$: high-quality information will be provided if and only if $\kappa \geq \mu/\beta$.*
- *(b) Increasing γ from 0 to $\mu/4$ incentivizes the PCP to provide high-quality information for $\kappa \in [\kappa^{h,l}, \mu/\beta]$.*
- *(c) Increasing γ from $\mu/4$ to $\mu/2$ incentivizes the PCP to provide low-quality information rather than no information if $\kappa \in [\kappa^{l,0}, \kappa^{h,l}]$. It does not change the amount of high-quality information provision. Increasing γ beyond $\mu/2$ does not change the PCP's information provision.*

Based on Lemma 1 and Proposition 1, we can formulate testable predictions for partially altruistic physicians for our specific experimental design. These Hypotheses L for the linear version of our model are presented in Section 4 after outlining our experimental design and procedures.

2.3. Provider behavior — non-linear PCP utility

If the PCP provides information, he can either gain additional profit or lose profit relative to the status quo before making a decision. Eventual gains or losses depend on the payment for information provision γ. Taking the option not to provide information does not change the PCP's payoff from the status quo. For $\gamma < \mu/2$, the PCP loses profit for both low- and high-quality information provision. For $\mu/2 \leq \gamma < \mu$, the PCP gains additional profit when passing on low-quality information and loses profit when passing on high-quality information. Finally, for $\gamma \geq \mu$, the PCP gains additional profit for both information qualities. In the linear version of our model, this aspect does not make a difference. Prospect theory, however, suggests that individuals' preferences are reference point dependent, that losses from this reference point are weighted more strongly than gains, and that the marginal value of both gains and losses decreases with their size (Tversky and Kahneman, 1991). In our case, PCPs may consider "not providing information" as a reference point since taking this action does not change their profits from the capitation payment which they receive no matter which action they take.[3] In order to study this possibility, we define the value function

$$V(\pi) := \begin{cases} \pi^{\sigma}, & \text{if } \pi \geq 0 \\ -\lambda(-\pi)^{\sigma}, & \text{if } \pi < 0. \end{cases} \tag{4}$$

The value function $V(\pi)$, with $\sigma \in (0,1]$ (smaller σ implies stronger curvature), loss aversion $\lambda > 0$, and decision profit $\pi(I) = \gamma(I) - c(I)$, is an asymmetrical S-shaped value function that reflects the three conditions above. The decision profit is defined as the extra gains or losses that PCPs make when providing information, i.e. the payment minus the cost of information provision. We assume that PCPs evaluate every decision about which information quality to provide in reference to the alternative that they do not provide any information. In this case, their decision profit equals 0 and their gross profit equals the capitation payment F_{PCP}. Fig. 2 depicts an exemplary value function dependent on the decision profit.

[2] The effect of γ on $\kappa^{l,0}$ is stronger than the effect on $\kappa^{h,0}$. This is the case because low-quality information provision is less effective and less expensive than high-quality information provision.

[3] This definition of the reference point follows Tversky and Kahneman (1991) who report on several studies that find a bias towards preserving the status quo in individuals. This can be explained by loss aversion if the individual considers the status quo, or equivalently the status quo preserving action, as the reference point. We consider alternative reference points in Appendix A.2 and find that predictions regarding high-quality information are similar to the predictions of the linear model if either "providing low-quality information" or "providing high-quality information" are the reference point.

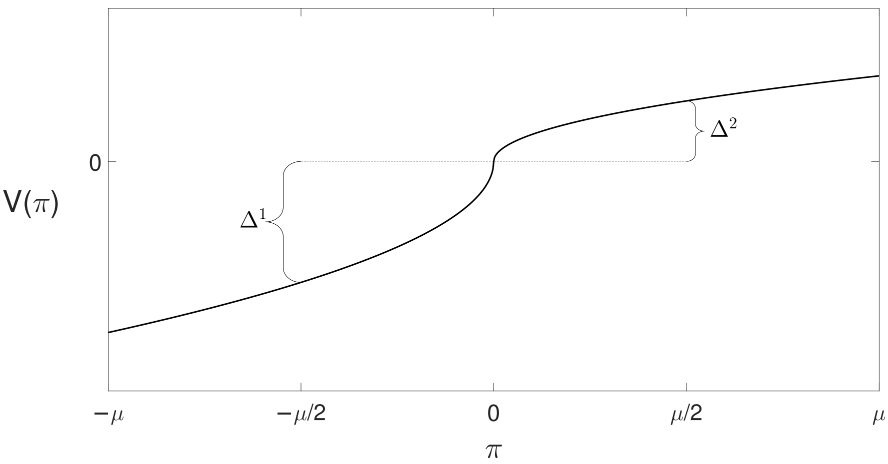


Fig. 2. Example of a Prospect Theory value function.

As in the linear version of our model, we assume that PCPs trade off the valuation of their own profit against altruistic benefits. Now, however, we replace the payments to the PCP ($p(I) - c(I)$) in the utility function with the value function $V(\pi)$ defined above. Then, PCP utility is captured by the functions

$$U_{PT}(I) := V(\pi(I)) + \beta b(I) \text{ and} \tag{5}$$

$$U_{PT}(I) := V(\pi(I)) + \beta s(I) \tag{6}$$

for the two cases in which the patient and the specialist, respectively, benefits from information provision. They replace the linear utility functions from Eqs. (2) and (3).

In Fig. 2, we illustrate a key difference in the prediction between the linear and non-linear model by comparing bonus payments that just cover the cost of either low- or high-quality information. Both models predict that for $\gamma \geq \mu/2$ all physicians are willing to provide at least low-quality information because its costs are covered. The linear model predicts that increasing γ beyond $\mu/2$ does not impact provided quality because the difference in profits between providing low- and high-quality information is constant.

In the non-linear model, this does not hold. For values of γ between $\mu/2$ and μ, low-quality information results in a gain and high-quality information results in a loss. Under Prospect Theory, if an individual is loss averse, the difference between a gain and the status quo is less salient than a same-sized difference between a loss and the status quo. This is illustrated in Fig. 2 for an exemplary value function. Given the payment $\gamma = \mu/2$, providing low-quality information yields no decision profit. High-quality information results in a loss of $\mu/2$. The utility difference is given by Δ^1. For $\gamma = \mu$, low-quality information results in a gain of $\mu/2$ and high-quality information results in a zero gain leading to a utility difference Δ^2. Loss aversion implies $\Delta^1 > \Delta^2$. An altruistic PCP weighs his valuation of patient benefit against his valuation of his decision profit. Thus, the non-linear model predicts more high- and less low-quality information provision when the bonus payment is increased from $\mu/2$ to μ.

Focusing on the case with positive altruism, Lemma 2 derives the boundaries for which physicians are indifferent between the different information qualities.

Lemma 2. *Under Prospect Theory, the decision boundaries for the PCP are given by*

$$\kappa^{l,0} = \frac{-3V(\gamma - \mu/2)}{\beta}$$

$$\kappa^{h,0} = \frac{-V(\gamma - \mu)}{\beta} \textit{ and}$$

$$\kappa^{h,l} = \frac{3}{2\beta}[V(\gamma - \mu/2) - V(\gamma - \mu)].$$

Lemma 2 follows directly from setting the relevant utilities equal and solving for κ (analogous to Lemma 1). Fig. 3 depicts the predictions for information provision depending on the parameters λ and σ for a fixed altruism parameter β. Note that the value function (4) nests the linear version of our model for $\lambda = \sigma = 1$. Therefore, the predictions for linear PCP utility are in the lower right subfigure.

We first consider the upper right subfigure of Fig. 3. Compared to the linear version of our model, only loss aversion λ is introduced. This shifts $\kappa^{h,l}$ to the right for $\gamma \in [0, \mu/2]$ since both quality choices are in the loss-domain. Thus, the difference in

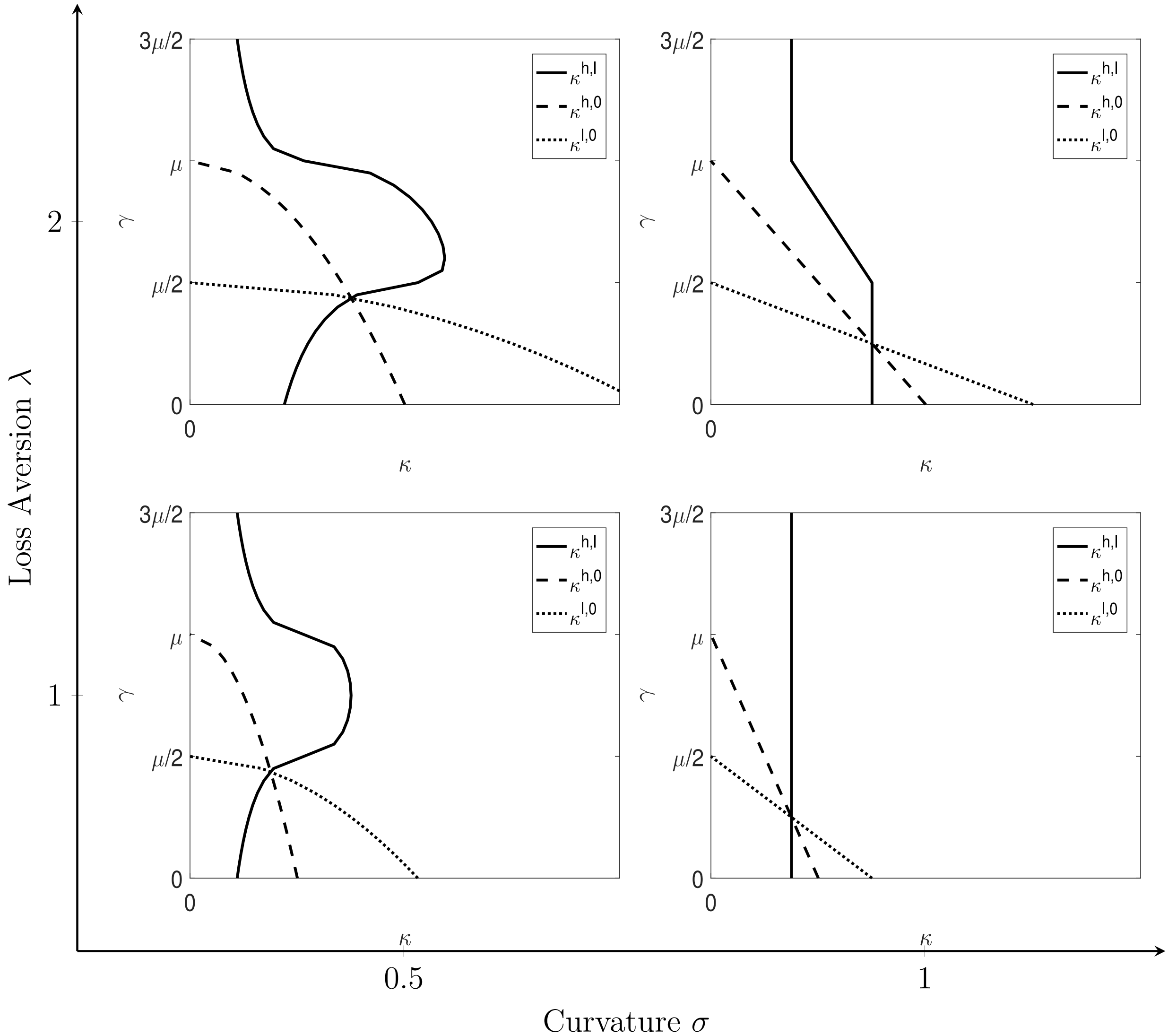


Fig. 3. Predictions for PCP information provision (Prospect Theory).

profits has a stronger effect on the PCP's value function and he will be less willing to provide information. For $\gamma \in [\mu/2, \mu]$, this effect decreases since providing low-quality information now yields a gain to the PCP. For $\gamma \geq \mu$, the effect is nullified and the same prediction as in the linear utility case emerges.

In the lower left subfigure, only the curvature of the value function is increased compared to the linear version of our model but no loss aversion exists. The result is a point symmetrical S-shaped value function. Several different behavioral predictions emerge. First, the intersection point of $\kappa^{h,l}, \kappa^{h,0}$ and $\kappa^{l,0}$ moves upward from $\mu/4$. It is now in the interval of $[\mu/4, \mu/2)$ (see proof for Proposition 2 in Appendix A.3). Second, increasing the payment γ beyond this point up to $3\mu/4$ increases the amount of low-quality information at the expense of high-quality information. The reason for this is that $V(\pi)$ is steepest near the reference point. For low-quality information, this reference point is passed at $\gamma = \mu/2$, whereas the profit from high-quality information is still well in the loss region where the value function is comparatively flat. Increasing γ beyond $3\mu/4$ reverses this effect. Now, more high-quality information is provided at the expense of low-quality information.

Finally, the upper left subfigure depicts the predictions under a value function for which both $\lambda > 1$ and $\sigma < 1$. The effects described above are combined. Proposition 2 (proof in Appendix A.3) describes the behavioral predictions of the non-linear version of our model when varying the bonus payment γ for the PCP.

Proposition 2.

Let $\beta > 0, \lambda > 1$, *and* $\sigma < 1$.

(a) Increasing γ from 0 to $\mu/4$ incentivizes the PCP to provide high-quality information rather than no information.
(b) Increasing γ from $\mu/4$ to $\mu/2$ incentivizes the PCP to provide more low- and less high-quality information.
(c) Increasing γ from $\mu/2$ to at least μ incentivizes the PCP to provide more high- and less low-quality information.

For larger λ, ceteris paribus, the effect sizes of all predictions are enhanced. For smaller σ, ceteris paribus, the effect size of prediction (a) is weakened and the effect on the other predictions is ambiguous.

Based on Lemma 2 and Proposition 2, we can again formulate testable predictions for our specific experimental design. These predictions specify differences to the predictions for the linear version of our model (Hypotheses L) and are summarized in Hypotheses NL in Section 4, which follows the description of the experimental design and procedures.

3. Experiment

3.1. Experimental design

In the experiment, subjects take the role of PCPs or specialists. They are matched in groups of two consisting of one PCP and one specialist. Subjects keep their role and partner throughout all decision tasks. In each decision task $t \in \{1, \ldots, T\}$, PCPs decide about the provision of information while referring their patient to the specialist. They can choose between no information (0), low-quality information (l), or high-quality information (h). Based on the information passed on, specialists automatically provide the respective optimal medical treatment in our experiment.[4] By implementing the optimal response, we ensure that PCPs know the exact consequences of their decision and exclude strategic uncertainty as well as risk perceptions as additional influencing factors in our design.[5] As in the seminal model of Ellis and McGuire (1986), patients are assumed to be fully insured and to accept any medical services provided.

We set the cost of providing high-quality information to $\mu = 5$ (and therefore for low-quality information to $\mu/2 = 2.5$) and implement different values for the bonus payment $\gamma \in \{0, 1.25, 2.5, 3.75, 5, 6.25\}$. If $\gamma < 2.5$, PCPs lose profit when passing on low- or high-quality information compared to passing on no information. If $2.5 < \gamma < 5$, they gain additional profit when passing on low-quality information but lose profit when passing on high-quality information. Finally, if $\gamma > 5$, they gain additional profit when passing on information of both qualities.

The benefit from providing high-quality information is κ and the benefit from low-quality information is $\kappa/3$. Our behavioral predictions indicate that PCPs change their choice of information provision depending on β, μ, λ, and σ (see Sections 2.2 and 2.3) . Since we neither know the individual altruism factor β nor the individual value function parameters λ and σ before the experiment, we choose a broad range of values for κ for the experiment: $\kappa \in \{0, 2, 4, 6, 8, 10, 12, 14, 16, 18\}$. Combining all values for γ and κ results in $T = 60$ decision tasks.

We test the theoretical predictions in five experimental conditions (see Table 2). We consider the extreme cases that only the patient or only the specialist benefits from information provision. In our baseline condition, P^H, the patient benefits from information provision and the PCP receives a capitation payment of $F_{PCP} = 30$. We set the specialist's capitation payment to $F_S^H = 62.5$ (high) and choose $\bar{c}_S = 20$ as the specialist's maximum costs. Hence, the PCP's profit is always lower than the specialist's profit. We use these specifications for the baseline condition because we assume that usually patients benefit from good communication between their physicians and because PCPs' earnings are lower than specialists' earnings in most OECD countries (OECD, 2015).

In the second condition, P^{CN}, we implement a version of the bonus payment γ that is cost-neutral for the payer. Paying a bonus payment to the physicians may not be cost-effective from the payer's perspective due to the increased costs. Thus, the payer may want to pay the bonus payment in a cost-neutral manner if this does not change the PCP's behavior too much. We implement this by varying the PCP's capitation payment based on the bonus payment. The other experimental parameters are the same as in P^H.

With the third experimental condition, we examine whether PCPs' information provision depends on who benefits from information provision. In condition S^H, only the specialist benefits from information provision in the form of a cost reduction. All other experimental parameters are the same as in P^H. Note that the specialist's maximum costs $\bar{c}_S = 20$ exceed the maximal possible cost reduction from information provision $\kappa^{\max} = 18$.

With the fourth and the fifth experimental condition, we investigate whether the relative payments of PCP and specialist or patient, respectively, influence the PCP's willingness to pass on information. Accordingly, we vary the size of the specialist's

[4] Although the decision of the specialist is set automatically, we use real subjects in the role of the specialist. Using computers instead of human subjects could potentially bias behavior as observed in studies on public good games (e.g., Houser and Kurzban, 2002) or on bargaining games (e.g., Johnson et al., 2002).

[5] We use this specification in order to investigate pure effects of the bonus payment. Following Tversky and Kahneman (1991), an aversion to lose from their reference profit might still affect PCPs' decisions in our riskless decision context.

Table 2
Experimental conditions.

Experimental condition	Beneficiary from information provision	$F_S \& \bar{b}$	F_{PCP}	Tasks	Groups	Number of subjects
$\mathbf{P^H}$	Patient	High	Fix	60	20	40
$\mathbf{P^{CN}}$	Patient	High	Varying	60	20	40
$\mathbf{S^H}$	Specialist	High	Fix	60	20	40
$\mathbf{S^L}$	Specialist	Low	Fix	60	20	40
$\mathbf{P^L}$	Patient	Low	Fix	60	20	40

capitation payment and the patient's base benefit $\bar{b}$ in these conditions. In conditions S^L and P^L, the specialist's capitation payment is reduced to $F_S^L = 27$ (low). Thus, the PCP's profit always exceeds the specialist's (or patient's) profit.[6]

Although no subject takes the role of a patient in our experiment, real patients outside the lab benefit from subjects' decisions. In particular, the monetary value of patient benefit is transferred to the German branch of Doctors of the World (Ärzte der Welt e.V., 80807 Munich, Germany) to support medical treatment for people who have no or only restricted access to the health care system in Germany. The specific procedure is described in the next section.

3.2. Experimental protocol

The computerized experiment was programmed with z-Tree (Fischbacher, 2007) and conducted at the Essen Laboratory for Experimental Economics (elfe) at the University of Duisburg–Essen, Germany, from October 2019 to January 2020.[7] We used the online recruiting system ORSEE (Greiner, 2015) to recruit the 200 participants.[8] As several experimental studies observe no qualitative differences in behavioral responses between medical and non-medical students as well as between medical students and physicians, we chose a conventional subject pool for our study.[9] While this pool of subjects allows identifying the quality of behavioral responses to bonus payments as argued before, we are still cautious with estimating effect sizes based on this pool.

Upon arrival in the laboratory, subjects were randomly assigned to cubicles in which the instructions had been placed before (see Appendix B.1 for the instructions). Once all subjects had finished reading the instructions, they were asked several questions about the decision setting (see Appendix B.2 for the comprehension questions). After answering the questions correctly, subjects were assigned their roles and partner which remained fixed over all 60 decision tasks. The order of the 60 decision tasks was once randomly selected and kept constant for all sessions.[10] In all experimental conditions, subjects were shown a table with the relevant information for their decision at the beginning of each task, including the resulting PCP profit, specialist profit, and patient benefit for the three options for information provision. All amounts were given in Euro and one of the 60 tasks was randomly chosen for payment at the end of the experiment. This procedure ensures that income effects that might potentially result from task repetition are excluded.

After the 60 decision tasks, we implemented the three series of pairwise lottery choices from Tanaka et al. (2010) as the second part of the experiment. The three series are designed such that subjects' choices can be used to measure the shape of their value functions according to prospect theory (Kahneman and Tversky, 1979). In particular, series one and two contain paired lotteries with only positive outcomes to determine the concavity of the value function (σ) and the probability weighting function. The paired lotteries in series three contain negative outcomes and can therefore be used to measure subjects' loss aversion parameter (λ). We enforced a monotonic switching point from option A to option B in each of the three series by showing an error message if subjects switched more than once. The amounts from Tanaka et al. (2010) were given in tokens and converted to Euro at an exchange rate of 10 tokens = 1.00 Euro. For each subject, one of the 35 lottery choices was randomly selected for payment and the chosen option was played at the end of the experiment.

[6] In the experimental conditions in which the patient benefits from information provision, the patient's benefit is specified as $B = \bar{b} + b(I)$. In order to keep the decision situation for PCPs comparable between conditions independent of who benefits from information provision, patients receive $\bar{b} = F_S - \bar{c}_S$ as base benefit from medical treatment in all experimental conditions. In conditions in which the specialist benefits from information provision, the patient benefit is reduced to $B = \bar{b}$. Since the fixed patient benefit $\bar{b}$ varies with the specialist's capitation payment F_S, the PCP's payment is always lower than the patient's benefit in conditions with the high payment for the specialist and always higher in conditions with the low payment for the specialist.

[7] Before conducting the experiment, it was approved by the German Association for Experimental Economic Research e.V. The purpose of the experiment and a short description of the experimental design were submitted for the review process and are included in the Institutional Review Board Certificate (No. zDgoJkzd: https://gfew.de/ethik/zDgoJkzd). As the analysis follows directly from our theoretical model and the experimental design, no pre-analysis plan was posted in addition.

[8] Table C.1 in Appendix C summarizes personal characteristics of subjects in the role of PCPs.

[9] See, e.g., Brosig-Koch et al. (2016a,b, 2017) or Hennig-Schmidt and Wiesen (2014). In particular, Brosig-Koch et al. (2016a,b, 2017) include a comparison of medical treatment decisions made by non-medical students and medical students recruited from a similar subject pool as we use for this study. For a short discussion see Galizzi and Wiesen (2018).

[10] We used the same order of tasks in all sessions to keep decisions comparable between different conditions. When we look at the provision of low- and high-quality information over time, we observe no systematic time trend.

As an approximation for subjects' general altruism, we measured their social value orientation (svo) using the decomposed game technique (Liebrand, 1984; McClintock and Liebrand, 1988; see also Brosig, 2002, for a description) in the third part of the experiment. In this part, amounts were again given in Euro and subjects were paid the sum of all amounts they allocated to themselves and all amounts another subject allocated to "other" in the 24 questions. Subjects were aware that there would be a second and third part of the experiment but only shown relevant instructions on screen when a part started. After the third part of the experiment, we asked subjects to complete a short questionnaire which contained questions on risk preferences (questions included in the German Socio Economic Panel, see Dohmen et al., 2011), questions on altruism (based on questions included in the European Values Study, European Values Study, 2015, in the World Values Survey, Inglehart et al., 2014, and in the Global Preference Survey, Falk et al., 2018), and questions on demographics (age, gender, nationality, and field of study).

Subjects in the role of PCPs earned on average 38.08 Euro (min = 27.50 Euro, max = 206.05 Euro) and subjects in the role of specialists earned on average 37.24 Euro (min = 7.60 Euro, max = 107.50 Euro) in the experiment.[11] In total, 3098.00 Euro were transferred to Ärzte der Welt e.V. At the end of each experimental session, we randomly selected a subject to monitor the transfer procedure. This subject controlled that a transfer order was correctly filled in and sent to the university's financial department. Therefore, the monitor and one experimenter put the order in an envelope and deposited it in the nearest mailbox. The monitor was paid 5 Euro in addition to his or her earnings from the experiment (see, e.g., Hennig-Schmidt et al., 2011, for a similar procedure). Each of the 10 experimental sessions lasted two hours at the most.

4. Hypotheses

Based on our theoretical model and our experimental design, we formulate specific hypotheses which we test in the experiment. We start with predictions for partially altruistic physicians derived from the linear version of our model (see Section 2.2), i.e. based on Lemma 1 and Proposition 1. All predictions are independent of the specific level of PCPs' altruism.

Hypotheses L.

1. *Increasing benefit κ, holding payment γ constant:*
   - (a) *The average amount of high-quality information (over all PCPs) increases in κ.*
   - (b) *For $\gamma > \mu/4 = 1.25$, the average amount of low-quality information (over all PCPs) decreases in κ.*
2. *Increasing payment γ, for an average over all benefits κ:*
   - (a) *PCPs do not provide low-quality information for $\gamma \leq \mu/4 = 1.25$.*
   - (b) *Increasing γ from 0 to $\mu/4 = 1.25$ increases the amount of high-quality information provision and does not affect low-quality information.*
   - (c) *Increasing γ from $\mu/4 = 1.25$ to $\mu/2 = 2.5$ increases the amount of low-quality information provision and does not affect high-quality information.*
   - (d) *All PCPs provide some information quality for $\gamma > \mu/2 = 2.5$.*
   - (e) *Increasing γ beyond $\mu/2 = 2.5$ does not have an effect on the provision of either information quality.*

Predictions from the non-linear version of our model (see Section 2.3) differ only with regard to increases in the bonus payment γ beyond $\mu/4$. Instead of Hypotheses L, 2. (c) and (e), we hypothesize based on Lemma 2 and Proposition 2:

Hypotheses NL.

Increasing payment γ, for an average over all benefits κ:

- (a) *Increasing γ from $\mu/4 = 1.25$ to $\mu/2 = 2.5$ decreases the amount of high-quality information.*
- (b) *Increasing γ from $\mu/2 = 2.5$ to at least $\mu = 5$ increases the amount of high-quality information provision and decreases low-quality information provision.*

All other predictions from Hypotheses L remain valid in the non-linear version of our model. In particular, both versions of our model imply that our results should be robust to the implementation of a cost-neutral version of the bonus payment, to a change of the beneficiary of information provision, and to a change of the payoff relation between the PCP and this beneficiary.

[11] Note that the large maximum payoffs are due to random draws made in the second part of the experiment in which subjects made pairwise lottery choices. Considering the first part of the experiment only, subjects in the role of PCPs earned on average 29.74 Euro (min = 25.00 Euro, max = 33.75 Euro) and subjects in the role of specialists earned on average 29.60 Euro (min = 7.00 Euro, max = 52.50 Euro).

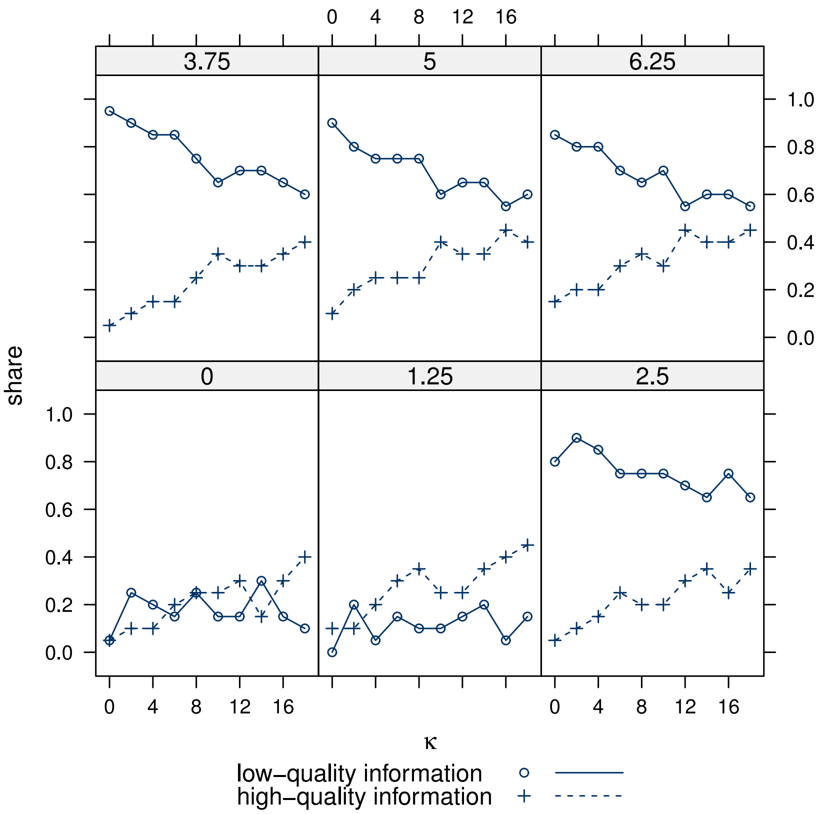


Fig. 4. Share of information passed on by κ (x-axis) and γ (boxes) in condition P^H.

5. Experimental results

In this section, we analyze the decisions made by subjects in the role of PCPs and test the explanatory power of our theoretical model.[12] Since our model includes altruism, we first look at the general social value orientation of subjects in the role of PCPs before comparing decisions between conditions. The social value orientation task, in which the subjects had to participate (see Section 3.2), provides a separate measure for subjects' altruism in a more neutral setting. The task originated in the psychological literature (e.g., Liebrand, 1984; McClintock and Liebrand, 1988), but is also used in economic studies (e.g., Brosig, 2002; Mill and Theelen, 2019). Over all conditions in our study, the provision of high-quality information in tasks without a bonus payment is positively correlated with subjects' social value orientation (Spearman's $\rho = 0.551$, $p < 0.001$) suggesting that the individual degree of altruism matters for information provision. As the social value orientation does not significantly differ between conditions (see Table C.2 in Appendix C), any differences between conditions cannot be explained by differences in subjects' general altruism.

In the following, we first test the predictions of our theoretical model in condition P^H, the baseline condition (Section 5.1). Afterwards, we investigate how a cost-neutral introduction of the bonus payment affects the provision of information (Section 5.2). In this subsection we also discuss whether a bonus payment is efficient from the payer's perspective. Finally, we check the robustness of our results with regard to a change of the beneficiary from information provision and a change of the payoff relation between the PCP and the beneficiary (patient or specialist; Section 5.3).

5.1. Test of model predictions in the baseline condition

In this subsection, we test if decision-making in the baseline condition P^H is in line with our theoretical predictions. Recall that patients benefit from information provision in condition P^H and that the PCPs' profits are always lower in this condition than the

[12] We use R 3.5.3 (R Core Team, 2019) for the data analysis.

Table 3
Effects of γ on information provision in condition P^H.

All PCPs ($N = 20$)

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.060	0.211	+	+	0.065	0.062
1.25 to 2.5	+	+	0.640	0.000	0	–	−0.055	0.250
2.5 to 6.25	0	–	−0.075	0.070	0	+	0.100	0.004

PCPs with $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$ ($N = 14$)

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.071	0.422	+	+	0.086	0.094
1.25 to 2.5	+	+	0.600	0.000	0	–	−0.079	0.250
2.5 to 6.25	0	–	−0.107	0.031	0	+	0.121	0.016

Note: Differences in average provision of low and high-quality information between γ_1 and γ_2. Reported p-values result from two-sided Wilcoxon matched-pairs signed-rank tests using average values over all κ for subjects. They test the null hypothesis that information provision does not differ between γ_1 and γ_2. The columns "Hyp. L" and "Hyp. NL" summarize predictions from Hypotheses L and NL, respectively.

specialists' profits (and the patients' benefits). Fig. 4 depicts the share of high- and low-quality information by values of γ (different boxes) and κ (x-axis) in condition P^H.

We can immediately make the following observations. Without a bonus payment ($\gamma = 0$), PCPs do not provide information in most observations. If information is provided, it is often of low quality (17.5% low quality, 21.0% high quality). This is consistent with empirical evidence (Bodenheimer, 2008; Mehrotra et al., 2011). Furthermore, Fig. 4 shows a strong increase of low-quality information provision to a share of around 80% from $\gamma < 2.5$ to $\gamma \geq 2.5$. Note that the costs for passing on low-quality information are $\frac{\mu}{2} = 2.5$. Therefore, PCPs do not lose profit or even gain additional profit if they pass on low-quality information and receive a bonus payment of $\gamma \geq 2.5$.

Let us now consider the Hypotheses from Section 4 in more detail. We start with Hypotheses L for the linear version of our model. *Variation in* κ (Hypotheses L, *part 1*):

Hypotheses L, *1. (a) The average amount of high-quality information (over all PCPs) increases in* κ.

In accordance with both versions of our model based on altruism, PCPs are more willing to provide high-quality information if it results in a larger benefit for patients. Over all values for γ, PCPs in condition P^H pass on high-quality information in only 13.3% of observations with $\kappa = 2$. For $\kappa = 18$, the share of high-quality information rises significantly to 40.8% ($p = 0.016$, two-sided Wilcoxon matched-pairs signed-rank test (WMP)).

Hypotheses L, *1. (b) For* $\gamma > 1.25$, *the average amount of low-quality information (over all PCPs) decreases in* κ.

Again, in line with the theoretical predictions, the share of low-quality information decreases distinctly with κ in tasks with $\gamma > \frac{\mu}{4} = 1.25$ (see Fig. 4). While PCPs pass on low-quality information in 85.0% of observations with $\gamma > 1.25$ and $\kappa = 2$, they do so in only 60.0% of tasks with $\gamma > 1.25$ and $\kappa = 18$ ($p = 0.031$).

These results show that our model can account for the changes in PCPs' information provision that result from a change in the benefit from this provision κ. Furthermore, it confirms that a considerable portion of PCPs are partially altruistic, i.e., they are willing to provide high-quality information only if the benefits are large enough. This is an important requirement for our hypotheses because additional high-quality information could not be incentivized with an increase in γ if all PCPs were fully egoistic or altruistic.

Variation in γ (Hypotheses L, *part 2* + Hypotheses NL): Next, we look at the influence of the bonus payment γ on PCPs' information provision. gives the difference in average low- or high-quality information provision between specific values for γ_1 and γ_2 over all values for κ for all subjects as well as respective theoretical predictions. Let us first consider the predictions of the linear version of our model, that is Hypotheses L, part 2.

Hypotheses L, *2. (a) PCPs do not provide low-quality information for* $\gamma \leq 1.25$.

Against our model's prediction, PCPs provide low-quality information in 14.5% of observations with $\gamma \leq \frac{\mu}{4} = 1.25$. This share differs significantly from zero ($p = 0.004$, two-sided Wilcoxon signed-rank test). This result could potentially be explained by a desire to at least provide some information and, thus, increase patient benefit, even if it is inefficient. In other words, the PCPs may value patient benefits in a non-linear way rather than a linear way as assumed by our model.

Hypotheses L, *2. (b) Increasing* γ *from 0 to 1.25 increases the amount of high-quality information provision and does not affect low-quality information.*

We observe that PCPs in condition P^H indeed pass on information of low quality similarly often in tasks with $\gamma_2 = 1.25$ as in tasks with $\gamma_1 = 0$ ($\Delta = -0.060$, $p = 0.211$, WMP), but pass on high-quality information somewhat more often ($\Delta = 0.065$, $p = 0.062$).

Hypotheses L, *2. (c) Increasing* γ *from 1.25 to 2.5 increases the amount of low-quality information provision and does not affect high-quality information.*

In line with the predictions, PCPs more often pass on information of low quality ($\Delta = 0.640$, $p < 0.001$) when the bonus payment increases from $\gamma_1 = 1.25$ to $\gamma_2 = 2.5$ and thus covers the costs for providing low-quality information ($\frac{\mu}{2} = 2.5$). There is no significant difference with regard to the provision of high-quality information ($\Delta = -0.055$, $p = 0.250$).

Hypotheses L, 2. (d) All PCPs provide some information quality for $\gamma > 2.5$.

For $\gamma > 2.5$, the bonus payment covers the costs for low-quality information provision. PCPs always pass on information. They provide low-quality information in 71.3% and high-quality information in 28.7% of observations with $\gamma > 2.5$.

Hypotheses L, 2. (e) Increasing γ beyond 2.5 does not have an effect on the provision of either information quality.

For an increase of the bonus payment beyond $\gamma = \frac{\mu}{2} = 2.5$, the linear version of our model predicts no changes in information provision. However, we observe that the share of low-quality information decreases somewhat ($\Delta = -0.075$, $p = 0.070$), while the share of high-quality information increases ($\Delta = 0.100$, $p = 0.004$) when the bonus payment increases from $\gamma_1 = 2.5$ to $\gamma_2 = 6.25$.

Since our experimental observations cannot be fully explained by the linear version of our model, we further test the non-linear version of our model in which we consider a value function which includes aversion to losses from a reference point in the PCP's utility function (see Section 2. Section 2.3). In contrast to the linear version, predictions of the non-linear version of our model differ only in Hypotheses NL which substitute Hypotheses L, 2. (c) and (e).

Hypotheses NL, (a) Increasing γ from 1.25 to 2.5 decreases the amount of high-quality information.

Although the share of high-quality information tends to decrease when the bonus payment increases from $\gamma_1 = 1.25$ to $\gamma_2 = 2.5$ ($\Delta = -0.055$), the difference is not significant ($p = 0.250$).

Hypotheses NL, (b) Increasing γ from 2.5 to at least 5 increases the amount of high-quality information provision and decreases low-quality information provision.

In line with the hypothesis, PCPs pass on information of low quality less often ($\Delta = -0.075$, $p = 0.070$) and information of high quality more often ($\Delta = 0.100$, $p = 0.004$) as the bonus payment increases from $\gamma_1 = 2.5$ to $\gamma_2 = 6.25$.[13] This implies that our experimental observations for higher bonus payments (i.e. $\gamma > 1.25$) are more in line with the non-linear version of our model which accounts for an aversion to losses from a reference point in the PCP's utility function than with the linear version.

Since predictions from Hypotheses NL are only valid for loss averse physicians with an S-shaped value function, we also analyze observations separately for subjects with $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$. We estimate the parameters $\hat{\lambda}$ and $\hat{\sigma}$ from subjects' decisions in the second part of the experiment. Table 3 gives the difference in average low- or high-quality information provision between γ_1 and γ_2 over all values of κ for subjects with $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$. Again, we find support for Hypotheses NL. Although the decrease in high-quality information provision between $\gamma_1 = 1.25$ and $\gamma_2 = 2.5$ is not significant also for this population, the share of information provided tends to change in the predicted direction.[14,15]

In order to take a closer look at the influence of loss aversion and the curvature of the utility function, we also analyze the effect of γ on information provision for PCPs with high or low values for $\hat{\lambda}$ and $\hat{\sigma}$ separately. According to Proposition 2 (see Section 2.3), effect sizes of predictions from the non-linear version of our model should be larger for higher values of λ. Consistent therewith, PCPs with higher $\hat{\lambda}$ tend to decide more in line with Hypotheses NL than PCPs with lower loss aversion (see Table C.4 in Appendix C). Regarding σ, Proposition 2 states that a smaller σ leads to a smaller increase of high-quality information between $\gamma_1 = 0$ and $\gamma_2 = \mu/4 = 1.25$. This is in contrast to our experimental results (see Table C.5 in Appendix C). Considered together with the above results, these observations suggest that PCPs' reactions to changes in the bonus payment are rather driven by loss aversion than by the curvature of the utility function.

Result 1. *Without a bonus payment, little information is provided with a considerable share of low-quality information. The introduction of a bonus payment increases the provision of both low- and high-quality information. PCPs provide less low- and more high-quality information as the benefit from information provision increases to at least cover the costs of high-quality information. This observed behavioral pattern is in line with the non-linear version of our model considering aversion to losses from a reference point in addition to altruism in the PCP's utility function.*

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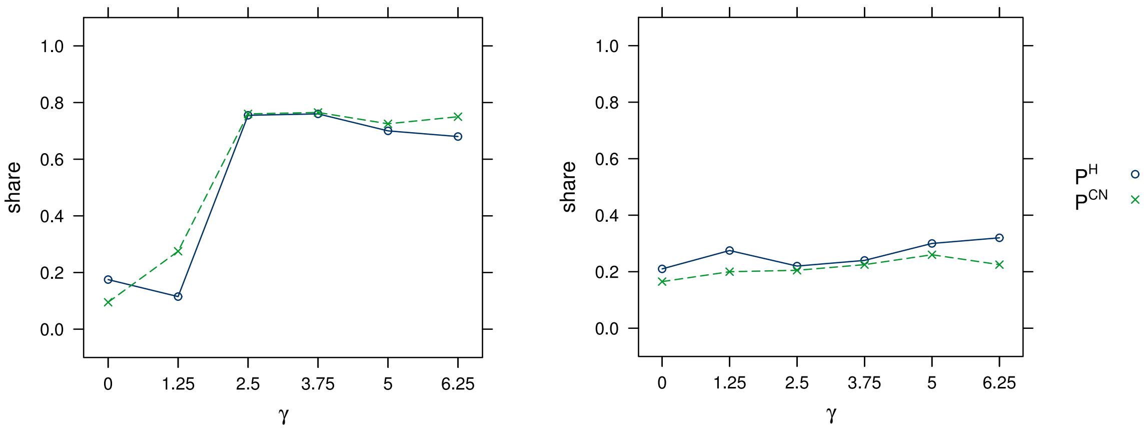
[13] We find qualitatively the same results when we consider a change from $\gamma_1 = 2.5$ to $\gamma_2 = 5$.

[14] On average, subjects in the role of PCPs have an estimated curvature of $\hat{\sigma} = 0.78$ and an estimated loss aversion $\hat{\lambda} = 3.22$ in the baseline condition P^H. Over all conditions, the values are $\hat{\sigma} = 0.71$ and $\hat{\lambda} = 3.14$. Thus, our PCPs are strongly loss averse but their value functions only show a moderate curvature on average. This may help to explain our weak results for Hypotheses NL, (a) and strong results for Hypotheses NL, (b) since (a) only holds for $\sigma < 1$, whereas (b) is mostly driven by loss aversion (see Fig. 3).

[15] We also analyze decisions of subjects who do not exhibit $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$ separately. The difference in average low- or high-quality information provision between γ_1 and γ_2 for these subjects is given in Table C.3 in Appendix C. The observed reactions to an increase in γ from these subjects are in line with predictions for changes in the share of low-quality information in the linear model. However, these subjects do not significantly change their rate of high-quality information with an increase in γ which is not in line with either version of our model. As only 6 subjects in the role of PCPs do not exhibit $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$, we are cautious drawing conclusions from these observations.



(a) Low-quality information (b) High-quality information

Fig. 5. Effects of γ on information provision in conditions P^H and P^{CN}.

5.2. Effects of a cost-neutral version of the bonus payment and welfare implications

In this subsection, we analyze how a cost-neutral version of the bonus payment influences information provision. For this purpose, we reduced the PCP's capitation payment by the costs which incur to the payer in expectation. More specifically, based on our theoretical predictions, PCPs receive $F^{var}_{PCP} = F_{PCP} - \gamma$ in tasks with $\gamma \geq 2.5$ in condition P^{CN}. For $\gamma < 2.5$, the theoretical predictions for information provision depend on the benefit from information provision κ and on physician altruism β. In order to estimate the costs for information provision for $\gamma < 2.5$, we conducted experimental sessions for condition P^H before determining the experimental parameters for P^{CN}. In condition P^H, PCPs pass on information of any kind in about 40% of observations with $\gamma < 2.5$. Assuming a similar rate for P^{CN}, we specify $F^{var}_{PCP} = F_{PCP} - 0.4\gamma$ for $\gamma < 2.5$. The actual amounts paid to PCPs are almost identical for all levels of γ, confirming that condition P^{CN} is indeed cost-neutral.[16]

Fig. 5 depicts the average low- and high-quality information provision in conditions P^H and P^{CN}. In line with our models that do not imply a difference between the PCPs' decisions made in conditions P^{CN} and P^H, subjects in the role of PCPs provide, on average, a similar share of low- and high-quality information in both conditions in the absence of a bonus payment ($\chi^2 = 0.052$, $p = 0.977$, multivariate Kruskal–Wallis test; see also Table C.6 in Appendix C) as well as over all values for γ ($\chi^2 = 0.035$, $p = 0.983$).[17]

As a result, we observe very similar responses to changes in γ in condition P^{CN} as in P^H. There is only one significant difference with regard to PCPs' responses between the two conditions: While the share of low-quality information significantly increases in P^{CN} between $\gamma_1 = 0$ and $\gamma_2 = 1.25$, there is no significant change in P^H (P^H: $\Delta = -0.060$, P^{CN}: $\Delta = 0.180$, $p < 0.001$, MWU).

Result 2. *Information provision is similar regardless of whether the bonus payment is designed cost neutrally or not.*

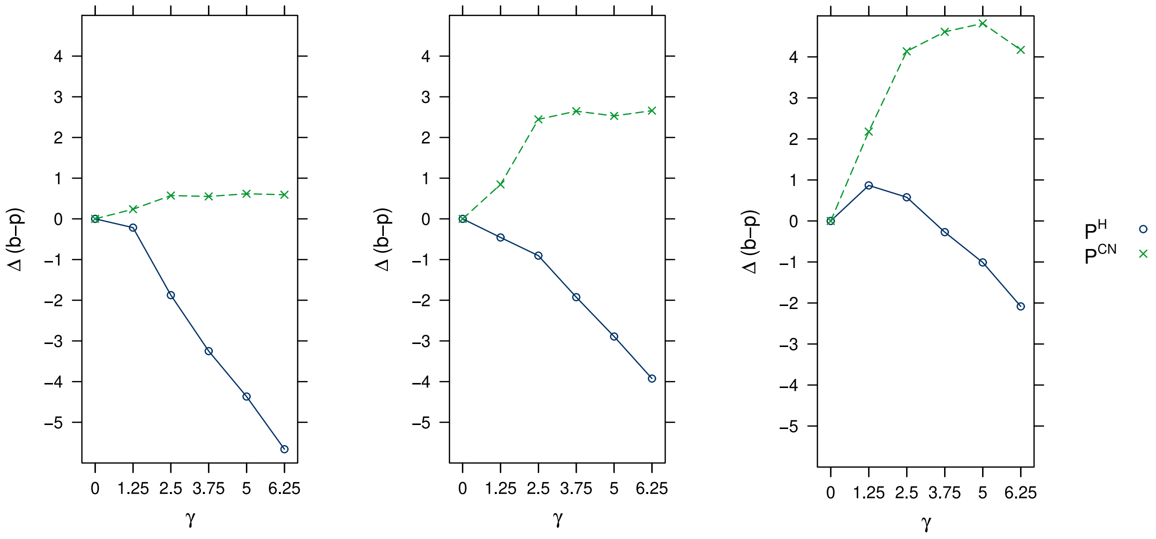
Now, we take a look at the welfare implications of our findings. We take the perspective of a payer who considers both the benefit of information provision b and his own payments p. The question we are interested in answering is whether the additional bonus payments are justified by the additional benefits from information provision. Fig. 6 shows $\Delta(b-p)$, the change in average payer welfare relative to $\gamma = 0$ ($\Delta(b-p) \equiv b(\gamma) - p(\gamma) - [b(\gamma = 0) - p(\gamma = 0)]$), depending on the bonus payment γ for different levels of κ in the baseline condition P^H and the cost-neutral condition P^{CN}. For the cost-neutral condition P^{CN}, an increase in γ is compensated by a decrease in the capitation payment F_{PCP}.

For the baseline condition P^H, Fig. 6 shows that a bonus payment is not effective for small and medium values of κ. As shown in Fig. 4, little low- and high-quality information is provided in this range for small values of γ and it generates only few benefits. If γ is increased to 2.5, low-quality information is triggered but it only provides little value. Furthermore, as only some PCPs change their information provision between two levels of γ, the payer's welfare additionally deteriorates for an increase in γ due to the extra payments to PCPs who already provide information for smaller bonus payments.

For large κ, however, $\gamma = 1.25$ and $\gamma = 2.5$ enhance payer welfare compared to $\gamma = 0$ with $\gamma = 1.25$ leading to the highest payer welfare. This is because the amount of high-quality information increases for $\gamma = 1.25$. For high values of κ, this enhances welfare.

[16] The amount paid to a PCP in tasks without bonus payments in conditions P^H and P^{CN} corresponds to 30 Euro. In condition P^{CN}, the amounts are in the range $[29.84, 30.09]$ over all values for γ.

[17] We perform an approximative version of the multivariate Kruskal–Wallis test (Puri and Sen, 1966, 1971) using the R package coin Hothorn et al. (2008).



(a) $\kappa < 5$ (b) $5 \leq \kappa < 14$ (c) $14 \leq \kappa$

Fig. 6. Average payer welfare (relative to $\gamma = 0$) depending on γ for different levels of κ.

Increasing γ to 2.5 yields more low-quality information which is less efficient from the payer's perspective. Increasing γ from 2.5 to at least 5 improves information quality. However, this effect cannot compensate for the increased costs of the bonus payment. Thus, large bonus payments are not efficient if their implementation is not cost-neutral.

In condition P^{CN}, payer welfare is always higher for a positive payment as the payer benefits from any type of information provision without extra costs. Due to the strong increase in low-quality information, payer welfare increases strongly from $\gamma = 0$ to $\gamma = 2.5$ for any positive level of κ. Additionally, if κ is large, a payment that covers the costs of high-quality information ($\gamma = 5$) performs best due to enhanced average information quality.

Result 3. *In the confines of our experiment, we find that if the payer is not able to implement the bonus payment in a cost-neutral manner, he should only pay a bonus payment if the benefit from information provision* κ *is sufficiently large. The bonus payment should not exceed half the costs for the provision of low-quality information (*$\gamma = 1.25$*). If the payer is able to implement the bonus payment in a cost-neutral manner, he should pay a larger bonus payment (e.g.,* $\gamma = 5$*).*

5.3. Robustness checks

In this subsection, we test whether our results obtained in the baseline condition are robust to a change of the beneficiary of information provision as well as to a change of the payoff relation between the PCP and the beneficiary. We first test whether PCPs pass on the same information if the specialist benefits from information provision instead of the patient. For this purpose, we compare decisions made in condition S^H to those made in the baseline condition P^H. Differences between both conditions might particularly occur if PCPs are more or less altruistic towards specialists than towards patients. According to our models, more altruistic physicians will supply more high-quality information for any level of bonus payment. Therefore, we focus on this type of information. As depicted in Fig. 7, PCPs less often pass on information of high quality if specialists benefit from information provision on average over all bonus payments for $\kappa > 0$ (5.8% versus 28.1%; $\chi^2 = 8.251$, $p = 0.011$, multivariate Kruskal–Wallis test; see also Table C.6 in Appendix C for values over all κ). This observation might be explained by a lower degree of altruism of PCPs towards specialists than towards patients, at least as long as the PCP receives a lower profit than the specialist and the patient, respectively.

We also test whether the type of the beneficiary matters for PCPs' information provision for the case that the PCP receives a higher profit than the beneficiary (condition S^L versus condition P^L). As shown in Fig. 7, PCPs pass on information of high quality similarly often if specialists instead of patients benefit from information provision over all bonus payments for $\kappa > 0$ (33.8% versus 38.4%; $\chi^2 = 3.026$, $p = 0.215$, multivariate Kruskal–Wallis test). Hence, we cannot reject the null hypothesis that PCPs are equally altruistic in both conditions.

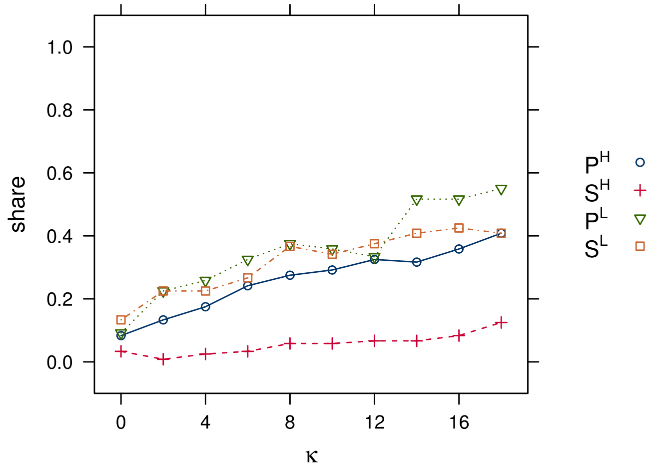


Fig. 7. Average high-quality information provision over all bonus payments γ over values for κ.

Result 4. *The beneficiary from information provision only matters for information provision when this beneficiary has a higher profit than the PCP. Then, PCPs pass on less high-quality information on average when specialists benefit from information provision than when patients benefit.*

In conditions S^L and P^L, specialists and patients receive a lower payoff than PCPs compared to conditions S^H and P^H. We can therefore test whether the payoff relation between the PCP and the beneficiary of information provision matters for PCP's behavior. We first compare PCPs' information provision between condition P^L and the baseline condition P^H. In both conditions, patients benefit from information provision. Although the share of high-quality information tends to be slightly larger in P^L than in P^H (see Fig. 7 and Table C.6 in Appendix C), information provision is not significantly different between the two conditions in tasks with $\kappa > 0$ ($\chi^2 = 2.765$, $p = 0.267$, multivariate Kruskal–Wallis test).

Next, we consider the scenario where specialists benefit from information provision, i.e., we compare PCPs' decisions made in condition S^L to those made in S^H. We observe that the share of high-quality information is significantly higher in condition S^L than in S^H when considering tasks with $\kappa > 0$ ($\chi^2 = 7.459$, $p = 0.020$, multivariate Kruskal–Wallis test; see Fig. 7). If $\kappa = 0$, PCPs pass on information of high quality in only a few cases (S^H: 3.3%, S^L: 13.3%).

Result 5. *The payoff relation between the PCP and the beneficiary of information provision only matters for PCPs' information provision when specialists benefit but not when patients do. When specialists benefit from information provision, PCPs pass on less high-quality information when specialists have higher earnings than when specialists have lower earnings than PCPs.*

Overall, our observations regarding the influence of the payoff relation between the PCP and the beneficiary of information provision and regarding the type of the beneficiary might be explained by a lower degree of altruism, which is revealed by PCPs if two conditions hold. First, PCPs earn less than the beneficiary of information provision and second, this beneficiary is a specialist and not a patient.

6. Conclusion

In order to study whether bonus payments for information provision can improve the information flow between physicians, we propose a theoretical model according to which PCPs can pass on information to specialists at a cost. Information can be of low or of high quality. We assume high-quality information to be more cost-effective and examine an agency problem in which the payer is not able to discriminate between low- or high-quality information and can only implement a bonus payment for information provision independent of its quality. Regarding the PCP's utility function, we consider both linear preferences and an aversion to losses from a reference point. Both versions of our model predict that partially altruistic PCPs provide more high-quality information when the benefit from information provision increases. Furthermore, a bonus payment for information provision induces the provision of low- and high-quality information. The hypotheses for partially altruistic PCPs regarding changes in the bonus payment depend on the assumed utility function. In contrast to a linear utility function, a non-linear model based on prospect theory predicts that high-quality information provision first decreases and then increases if the bonus payment is raised.

We test the theoretical predictions in a controlled laboratory experiment that allows to observe ceteris paribus variations of parameters. Our results confirm the empirical observation that little information is passed on without a bonus payment and that a considerable share of the information is of low quality. In line with our hypotheses, PCPs provide less low- and more high-quality information as the benefit from information provision increases. PCPs pass on more information on average as the bonus payment increases. Average information quality increases if the bonus payment covers the costs of high-quality information provision instead of covering only the costs of low-quality information. This observed behavioral pattern is in line with the non-linear version of our model considering an aversion to losses from a reference point in addition to altruism. These results hold independently of whether the bonus payment is designed cost-neutrally or not. Overall, paying for information provision is cost-effective from a payer's perspective mostly if the benefits are high and the bonus payment at most covers the costs for providing information of low quality. An exception is the cost-neutral introduction of a bonus payment. In this case, a bonus payment that covers the costs for high-quality information performs well in our experiment.

Checking the robustness of our results with regard to changes in the decision-setting, we find that the provision of high-quality information depends on an interaction of who benefits from information provision and the payoff relation between beneficiaries and PCPs. On average, PCPs pass on less high-quality information when specialists benefit from information provision and specialists have higher earnings than PCPs, indicating less concern for the payoff of the high earning specialist.

Our experimental study based on a theoretical model sheds light on a number of key issues pertaining to the information provision between physicians and may therefore be informative for the design of programs which seek to improve information exchange. In particular, our results indicate that bonus payments may lead to a considerable amount of low-quality information provision. Paying for information in form of extra bonuses may therefore generate only little welfare gains. This favors bonus schemes which are financed by the reduction of other payment components. Nevertheless, we also find that information quality can increase with a larger bonus payment. Therefore, if high-quality information provision is very important, it may be efficient to use payments which exceed the costs of low-quality information provision. Still, one should be cautious in interpreting these findings, since our experimental analysis relied on assumptions on parameters for which no empirical estimates are yet available. Future work may aim at modeling more closely actual information provision bonus programs and the costs and benefits involved.

Furthermore, our results indicate that unequal incomes between PCP and specialist may deteriorate physician cooperation. However, we did not consider potentially mediating influences like the additional years of schooling that are required for specialization. These differences may justify differences in pay for the PCP from a fairness perspective and, thus, may ameliorate the problem. What we do find in our study is that the behavioral responses to differences in the relation of the beneficiary's level of profits to one's own disappear when the beneficiary is a patient, i.e. in our case people who have no or only restricted access to the health care system in Germany.

We contribute to the literature on prospect theory by showing that the inclusion of loss aversion improves our model's predictions regarding the supplied information quality. This supports the application of prospect theory in a riskless context. Moreover, our study considers the interaction of loss aversion and altruism. For dictator games[18] there is mixed evidence regarding the impact of a loss frame on altruistic behavior. Some studies find enhanced altruism, while others find diminished altruism (see the survey by Feng et al., 2021). In our setting, only the PCP is affected by a potential loss. Consistently with predictions based on loss aversion, we find a reduced willingness to act altruistically if the PCP faces a loss by doing so. Thus, our results suggest that loss aversion has a potentially negative effect on altruistic behavior if only the PCP faces a potential loss.

In our study, we did not consider a number of factors which could also influence physicians' information provision. In particular, not providing adequate information to specialists may affect the demand for visits that the primary care physician faces, it may alter long-term relationships with specialists, or it may affect malpractice lawsuit risk. Insurers may also use direct performance pay as an incentive for providing high-quality information. Further research might implement these factors to study their effects on information provision. For example, the first two factors might be studied in a laboratory experiment that allows patients to choose physicians and by considering repeated interactions between primary care physicians and specialists. If physicians are affected by these quality incentives, this may imply that the bonus payment need not cover the full costs of high-quality information in order to improve information quality.

There are yet more options to improve the flow of information between physicians. For instance, physicians could adopt interoperable electronic health records in order to lower the costs of information transfer. This would correspond to a lower cost factor μ

[18] Note that the PCP's decision made in our experiment relates to some degree to giving in a dictator game that is also typically associated with altruism. In the standard version of this "game" the dictator receives a fixed amount of money and determines how this amount is divided between the dictator and a second person, the recipient. According to the literature on the dictator game (for an overview see Engel, 2011), dictators give on average 28% of their initial endowment. About 36% of all participants give nothing and about 17% choose the equal split. In comparison, PCPs in the baseline condition P^H provide no information in 58.3%, low-quality information in 18.9%, and high-quality information in 22.8% of observations with $\gamma = 0$ and $\kappa > 0$. The differences in behavior might be due to that our experimental set-up still differs in some aspects from that of a dictator game. We implement a different strategy space, a different decision frame, and vary the benefit resulting from high-quality information. Furthermore, in our setting efficiency gains (losses) between PCP and beneficiary are possible if $\gamma > (<)\mu$, whereas typically in dictator games efficiency is unaffected by allocation decisions. Each of these aspects can influence behavior making it difficult to directly compare decisions. For example, Ahlert et al. (2012) study allocation decisions and find differences in behavior between a neutral and a medical decision frame. Whereas economics students behave less selfishly in the medical frame, surprisingly medical students are closer to own-payoff maximization in the medical frame. Also comparing decisions between a medical and a neutral frame, Kesternich et al. (2015) find no significant difference though.

in our model. Correspondingly, a lower information payment would be needed to improve information quality. Another possibility is for the physicians to form a physician team that employs internal cost sharing to incentivize information provision. This may be especially effective if specialists benefit from information provision. Again, this is a fruitful topic for future research. A further interesting extension would be to examine the interaction of the cost of information provision and referrals. Primary care physicians' decisions whether or not to refer out in the first place may be influenced by the cost of information sharing.

Previous studies that examine the provision of medical services have found no systematic differences between non-medical students, medical students and physicians (see footnote Section 3.2). However, it remains an open question whether our results on information provision for this student sample can be generalized to a real medical setting. A natural avenue for further research would therefore be a field experiment. A first step in this direction would be to extend our study and run an artefactual field experiment with real physicians as participants (see Brosig-Koch et al., 2016b).

Appendix A. Mathematical appendix

A.1. Proof of Proposition 1

Proof.

(a) $\kappa^{h,l} \le \kappa^{l,0} \iff \gamma \le \mu/4 \iff \kappa^{h,0} \le \kappa^{l,0}$.

If the PCP is willing to provide low-quality information rather than no information at all, this implies $\beta\kappa/3 \ge \mu/2 - \gamma$. For $\gamma \le \mu/4$, this implies $U(h) = \beta\kappa - \mu \ge \beta\kappa/3 - \mu/2 = U(l)$ and therefore the PCP prefers providing high-quality information rather than low-quality information. This implies that, if $\gamma = 0$, the PCP will provide high-quality information for $\kappa \ge \kappa^{h,0}(\gamma = 0) = \mu/\beta$ and will provide no information otherwise.

(b) $\partial\kappa^{h,0}/\partial\gamma < 0$ and $\mu/\beta > \kappa^{h,l}$.

Hence, as long as $\kappa^{h,0} \ge \kappa^{h,l} \iff \gamma \le \mu/4$, high-quality information provision increases. For $\gamma = \mu/4, \kappa^{h,0} = \kappa^{h,l} = \kappa^{l,0}$ and for any $\kappa \ge \kappa^{h,l}, I^* = (1, h)$.

(c) $\kappa^{h,l} \ge \kappa^{l,0} \iff \gamma \ge \mu/4$ and $\partial\kappa^{l,0}/\partial\gamma < 0$.

Therefore, more low-quality information is provided for $\kappa \in [\kappa^{l,0}, \kappa^{h,l}]$ with rising γ. Since $\kappa^{h,0} \ge \kappa^{l,0} \iff \gamma \ge \mu/4$, no further high-quality information is provided. Changing γ does not impact whether a PCP prefers low- or high-quality information for a given κ. Hence, the provision of high-quality information remains unchanged. For $\gamma = \mu/2$, $\kappa^{l,0} = 0$. Therefore, there is no increased information provision beyond this point. □

A.2. Alternative reference points

In Section 2.3, we consider "not providing information" as a reference point. Let us now consider the qualitative predictions of the model when the reference point is either "providing low-quality information" or "providing high-quality information". These cases may be relevant for altruistic physicians who expect to provide some level of information quality. We start with the first case.

If "providing low-quality information" is the reference point, the decision profit in the reference point becomes $\pi_{ref} := \gamma - \mu/2$. In this case, physicians are making gains (losses) compared to not providing information if the bonus payment is smaller (larger) than the costs for low-quality information provision. Furthermore, physicians always make losses when providing high-quality information since the profits from providing high-quality information are always lower than profits from providing low-quality information. The critical κ describing physician behavior are given by

$$\kappa^{l,0} = \frac{3V(-\pi_{ref})}{\beta}$$
$$\kappa^{h,0} = \frac{V(-\pi_{ref}) - V(-\mu/2)}{\beta} \text{ and}$$
$$\kappa^{h,l} = \frac{-3}{2\beta}V(-\mu/2).$$

The critical values of κ in the non-linear model with reference point l are depicted in Fig. A.1.

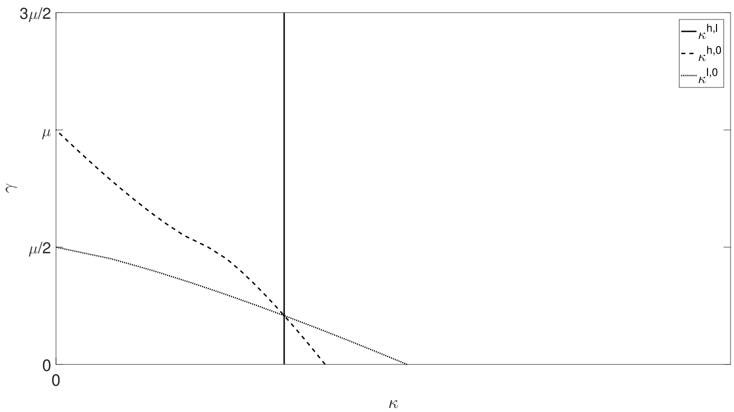
We can make the following observations for a fixed β. For $\pi_{ref} \ge 0$ it holds that $\kappa^{l,0}, \kappa^{h,0} < 0$. Consequently, all physicians provide some information quality in this case. $\kappa^{h,l}$ determines the critical κ for which either low- or high-quality information is provided. Since it is independent of γ, increasing γ beyond $\mu/2$ does not affect incentives, similarly to the linear model. Let $\pi_{ref} < 0$, then

$$\kappa^{l,0} = \kappa^{h,0} = \kappa^{h,l} \iff$$
$$\gamma = \frac{\mu/2(2^{1/\sigma} - \lambda^{1/\sigma})}{2^{1/\sigma}}$$

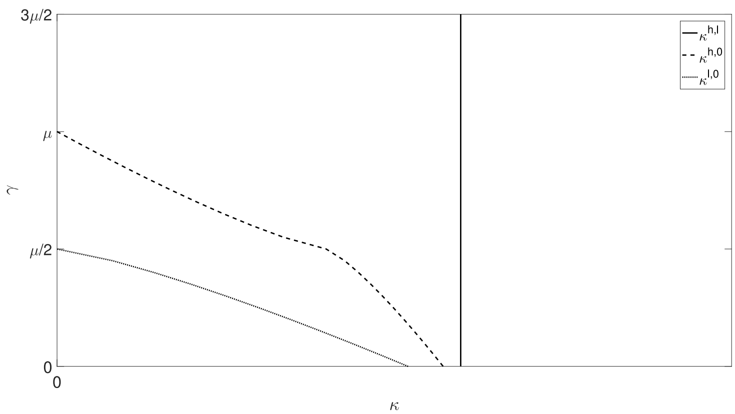
The right side term is strictly positive if and only if $\lambda < 2$. Now, consider the case $\gamma = 0$. We find

$$\kappa^{l,0} - \kappa^{h,0} = \frac{(2-\lambda)(\mu/2)^{\sigma}}{\beta}.$$

The term is strictly positive if and only if $\lambda < 2$. We can conclude the following qualitative predictions in Proposition 3.



(a) $\lambda < 2$



(b) $\lambda > 2$

Fig. A.1. Critical values of κ with l as reference point.

Proposition 3. *Let l be the reference point, $\beta > 0, \lambda > 1$, and $\sigma < 1$.*

(a) If $\lambda < 2$, only high-quality information or no information is provided for $\gamma = 0$. Increasing γ from 0 to $\mu/2$ incentivizes the PCP to provide both low- and high-quality information rather than no information.
(b) If $\lambda \geq 2$, some low-quality information is provided for $\gamma = 0$. Increasing γ from 0 to $\mu/2$ incentivizes the PCP to provide low-quality information rather than no information.
(c) Increasing γ from $\mu/2$ does not change information provision.

Let us now consider the case that physicians consider the provision of high-quality information as a reference point. Then the decision profit in the reference point becomes $\pi_{ref} := \gamma - \mu$. In this case, physicians are making gains (losses) from not providing information if the bonus payment is smaller (larger) than the costs for high-quality information provision. If physicians provide low-quality information, they always receive a gain in profits. The critical κ describing physician behavior are given by

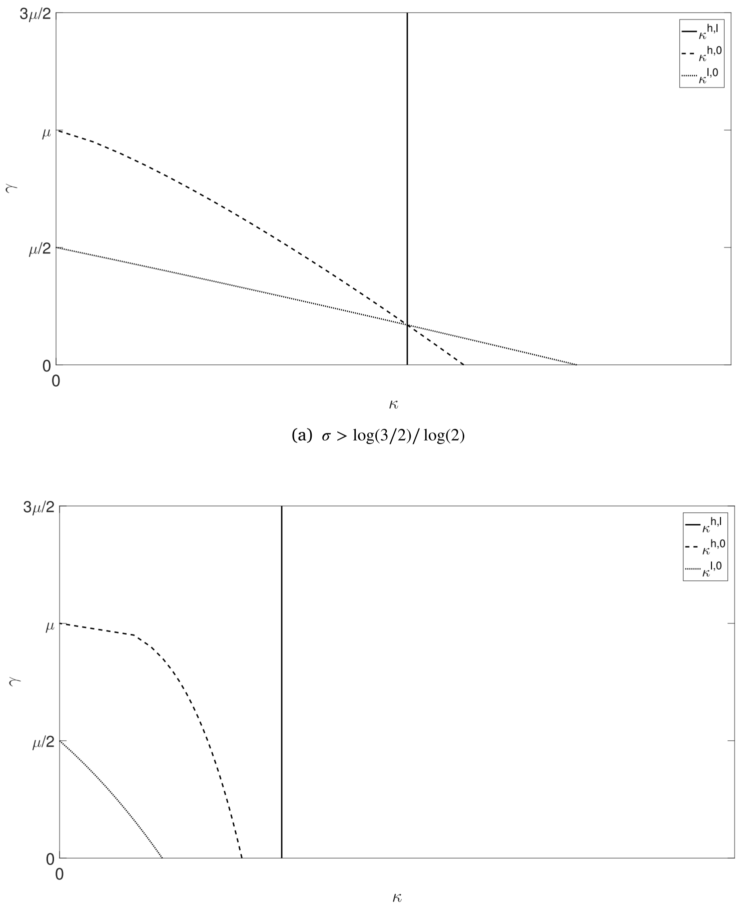
$$\kappa^{l,0} = \frac{3(V(-\pi_{ref}) - (\mu/2)^{\sigma})}{\beta}$$

$$\kappa^{h,0} = \frac{V(-\pi_{ref})}{\beta} \text{ and}$$

$$\kappa^{h,l} = \frac{3}{2\beta}(\mu/2)^{\sigma}.$$

The critical values of κ in the non-linear model with reference point h are depicted in Fig. A.2.

We can make the following observations for a fixed β. For $\gamma \geq \mu/2$ it holds that $\kappa^{l,0} < 0$. Consequently, all physicians provide some information quality in this case. $\kappa^{h,l}$ determines the critical κ for which either low- or high-quality information is provided.



(a) $\sigma > \log(3/2)/\log(2)$

(b) $\sigma < \log(3/2)/\log(2)$

Fig. A.2. Critical values of κ with h as reference point.

Since it is independent of γ, increasing γ beyond $\mu/2$ does not affect incentives, similarly to the linear model. Let $\gamma < \mu/2$, then

$$\kappa^{l,0} = \kappa^{h,0} = \kappa^{h,l} \iff$$
$$\gamma = \mu(1 - (3/2)^{1/\sigma}/2)$$

The right side term is strictly positive if and only if $\sigma > \log(3/2)/\log(2)$. Additionally, it cannot exceed $\mu/4$ if $\sigma \leq 1$. Now, consider the case $\gamma = 0$. We find

$$\kappa^{l,0} - \kappa^{h,0} = \frac{2\mu^\sigma - 3(\mu/2)^\sigma}{\beta}.$$

The term is strictly positive if and only if $\sigma > \log(3/2)/\log(2)$. We can conclude the following qualitative predictions in Proposition 4.

Proposition 4. *Let h be the reference point, $\beta > 0, \lambda > 1$, and $\sigma < 1$.*

(a) If $\sigma > \log(3/2)/\log(2)$, only high-quality information or no information is provided for $\gamma = 0$. Increasing γ from 0 to $\mu/2$ incentivizes the PCP to provide both low- and high-quality information rather than no information.
(b) If $\sigma \leq \log(3/2)/\log(2)$, some low-quality information is provided for $\gamma = 0$. Increasing γ from 0 to $\mu/2$ incentivizes the PCP to provide low-quality information rather than no information.
(c) Increasing γ from $\mu/2$ does not change information provision.

Concluding, if either l or h are the reference point, predictions are similar to the predictions of the linear model. Most importantly, increasing γ beyond $\mu/2$ does not change information provision. In contrast to the linear model, low-quality information can be provided for low levels of γ. Overall, we believe that considering the reference point of "not providing information" generates more interesting predictions. Furthermore, our experimental results suggest that physicians improve their information quality if γ is increased from $\mu/2$ to at least μ. This supports our choice of reference point.

A.3. Proof of Proposition 2

Proof. Let $\beta > 0$ be fixed. First, note that $\kappa^{h,l} = \kappa^{h,0} = \kappa^{l,0} \iff \gamma = \frac{\mu(1-3^{1/\sigma}/2)}{1-3^{1/\sigma}} \in [\mu/4, \mu/2)$. Therefore, for $\gamma \le \mu/4$, PCPs provide no information if $\kappa \le \kappa^{h,0}$ and high-quality information if $\kappa \ge \kappa^{h,0}$. For $\gamma \ge \mu/2$, PCPs provide low-quality information if $\kappa \le \kappa^{h,l}$ and high-quality information if $\kappa \ge \kappa^{h,l}$.

(a) $\kappa^{h,0}(\gamma = \mu/4) - \kappa^{h,0}(\gamma = 0) = \lambda/\beta[(3\mu/4)^\sigma - \mu^\sigma] < 0$

This implies that the minimum κ for which the PCP is indifferent between supplying h and 0 shrinks. Therefore, the PCP is incentivized to play $I^* = h$ rather than $I^* = 0$. Further,

$$\frac{\partial}{\partial\lambda}\lambda/\beta[(3\mu/4)^\sigma - \mu^\sigma] < 0$$
$$\frac{\partial}{\partial\sigma}\lambda/\beta[(3\mu/4)^\sigma - \mu^\sigma] = \lambda/\beta[(3\mu/4)^\sigma \log(3\mu/4) - \mu^\sigma \log(\mu)] < 0.$$

Therefore, the difference in the provision of high-quality information is larger for larger λ or σ.

(b) $\kappa^{h,l}(\gamma = \mu/2) - \kappa^{h,0}(\gamma = \mu/4) = \lambda/\beta[3/2(\mu/2)^\sigma - (3\mu/4)^\sigma] > 0$

Further,

$$\frac{\partial}{\partial\lambda}\lambda/\beta[3/2(\mu/2)^\sigma - (3\mu/4)^\sigma] > 0$$
$$\frac{\partial}{\partial\sigma}\lambda/\beta[3/2(\mu/2)^\sigma - (3\mu/4)^\sigma] = \lambda/\beta[3/2(\mu/2)^\sigma \log(\mu/2) - (3\mu/4)^\sigma \log(3\mu/4)] \lesseqgtr 0.$$

(c) Let $w \ge 0$, then

$$\kappa^{h,l}(\gamma = w + \mu) - \kappa^{h,l}(\gamma = \mu/2) = \frac{3}{2\beta}[(w + \mu/2)^\sigma - w^\sigma - \lambda(\mu/2)^\sigma] < 0.$$

Further,

$$\frac{\partial}{\partial\lambda}\frac{3}{2\beta}[(w + \mu/2)^\sigma - w^\sigma - \lambda(\mu/2)^\sigma] < 0$$
$$\frac{\partial}{\partial\sigma}\frac{3}{2\beta}[(w + \mu/2)^\sigma - w^\sigma - \lambda(\mu/2)^\sigma] =$$
$$\frac{3}{2\beta}[(w + \mu/2)^\sigma \log(w + \mu/2) - w^\sigma log(w) - \lambda(\mu/2)^\sigma \log(\mu/2)] \lesseqgtr 0. \quad \square$$

Appendix B. Information on the experiment

B.1. Instructions of the experiment (translated from german)

Note that the instructions refer to condition P^H. The text in squared brackets [] denotes changes for other conditions.

Welcome to the experiment!

You are participating in a study on decision-making in experimental economics research. During the experiment, you are asked to make decisions. By doing so, you can earn money. How much money that is depends on your decisions and on the decisions of other participants.

Immediately after the experiment, all participants are paid individually in cash. Please stay therefore seated after the experiment until your cubicle number is called.

The experiment takes about 120 min including the payment procedure and consists of three different parts. Presumably, part 1 takes considerably longer than part 2 and part 3. Before each of the three parts of the experiment, you receive detailed instructions. Please note that your decisions in one part of the experiment do not have any influence on another part of the experiment.

In part 1 and 3 of the experiment, all amounts are given in Euro. In part 2 of the experiment, all amounts are given in tokens. During the experiment, no participant receives any information about the identity of other participants.

Part 1

Please read the following instructions carefully. In case you have questions, you can raise your hand or open the door at any time. We will then come to your cubicle and answer your question.

In the first part of the experiment, you are taking part in 60 decision periods. There are participants in the role of primary care physicians and participants in the role of specialists. At the beginning of the first decision period, one of the two roles, primary care physician or specialist, is randomly assigned to you. You keep your role during all 60 decision periods. Each primary care physician is matched with one specialist. This matching is also retained during all decision periods.

Description of the decision periods

In each of the 60 decision periods, the primary care physician refers a patient to the specialist. The primary care physician has examined the patient and has information on the diagnosis. The primary care physician cannot treat the patient himself but needs to refer the patient to the specialist for treatment. With the referral, the primary care physician can pass on information on the diagnosis to the specialist. He has three options for this:

i He can pass on no information. This will incur no costs for information provision.
ii He can pass on information of low-quality. This will incur costs of 2.50 Euro.
iii He can pass on information of high-quality. This will incur costs of 5.00 Euro.

The costs for information provision are kept constant for all decision periods and are displayed on screen at the beginning of each period as a reminder. When the primary care physician passes on information to the specialist, there is an additional benefit for the patient [*S:* a cost reduction for the specialist]. The size of the benefit [*S:* the cost reduction] depends on the information quality and may vary between decision periods. The primary care physician is displayed the benefit for the patient [*S:* the cost reduction for the specialist] from information provision on screen for each of the three options for information provision at the beginning of each period. Based on the information passed on by the primary care physician, the examination and treatment decision which is optimal for the patient is made automatically for the specialist. Real patients will benefit from the monetary value of patient benefit (see section “Payment”).

Physician income and patient benefit

The primary care physician receives a capitation payment of 30 Euro in each period. [*CN:* The primary care physician receives a capitation payment in each period.] If he passes on information about the diagnosis to the specialist, he also receives an additional bonus payment. The size of the bonus payment [*CN:* The size of the capitation payment depends on the size of the bonus payment. The latter] is independent of the information quality and may differ between decision periods. The size of the [*CN:* capitation payment and the size of the] bonus payment is displayed on screen to the primary care physician at the beginning of each period.

The specialist receives a capitation payment of 62.50 Euro [*L:* 27 Euro] in each period. He incurs costs for the diagnosis of 20 Euro. [*S:* If the primary care physician passes on information on the diagnosis to the specialist, the information provision reduces the specialist’s costs.]

Income of the primary care physician =
30.00 (Capitation payment) [*CN:* Capitation payment]
- Costs for information provision (Costs primary care physician)
+ Bonus payment for information provision

Income of the specialist =
62.50 [*L:* 27] (Capitation payment)
- 20.00 (Costs specialist)
[*S:* + Cost reduction from information provision]

The patient receives a benefit of 42.50 Euro [*L:* 7 Euro] from treatment in each period. If the primary care physician passes on information for the diagnosis to the specialist, the patient receives an additional benefit from information provision.

Patient benefit =
42.50 [*L:* 7] (Benefit from treatment)
+ Benefit from information provision

Payment

Upon completion of part 1, one of the 60 decision periods is randomly selected for payment. The payment of physicians or patients are determined from this period. The payment results from the income or benefit in this period. This amount is paid out in cash at the end of the experiment together with the earnings from the other parts of the experiment.

In this part of the experiment, no participants in the role of patients are physically present in the laboratory. Real patients benefit from the patient benefits resulting from the decisions made in the randomly selected period. The monetary value of these benefits in Euro is provided for national projects of Ärzte der Welt e.V., 80807 Munich. These projects provide basic health care for people in Germany who do not have health insurance or for other reasons do not have access to the health system. Ärzte der Welt e.V. bears the DZI Seal-of-Approval which certifies that the donations are used transparently, purposefully and economically.

After the experiment, the amount is transmitted to Ärzte der Welt e.V. by the experimenter together with a control person. The control person enters the amount in Euro, which results from the realized patient benefits of the randomly selected round, into a form for payment order to Ärzte der Welt. The payment of the amount from the funds earmarked for this experiment is then arranged by the financial administration of the University of Duisburg–Essen to Ärzte der Welt. The form is placed in a postpaid envelope addressed to the finance department of the University of Duisburg–Essen. This envelope is then posted in the nearest mailbox by the control person together with the experimenter.

After part 3 of the experiment, one participant is randomly chosen as the control person. The control person receives a compensation of 5 Euros for this task in addition to the payment from the experiment. The control person confirms by signing a statement which can be viewed by all participants in the office of the Chair of Quantitative Economic Policy (Room WST-A.10.08) that he/she has correctly fulfilled the tasks described here. All participants of the experiment may upon request also see a payment receipt from Ärzte der Welt in the office of the above-mentioned chair.

The payment for part 1 is only made at the end of the experiment. Not until then you will be shown the payment information on screen.

Prior to the 60 decision periods, we ask you to complete a comprehension test on screen. The decision periods will start as soon as all participants have answered the comprehension questions correctly. These questions do not affect your payment.

Part 2 and part 3

The instructions for part 2 and part 3 of the experiment will appear on screen when the part starts. In part 2, all amounts are given in tokens, in part 3 all amounts are given in Euro.

At the end of the experiment, your earnings from part 2 are converted to Euro. Subsequently, your earnings from all three parts of the experiment are added up and paid to you in cash.

After part 3 of the experiment, a questionnaire opens. The payment procedure starts after all participants have answered the questionnaire completely.

Part 2 (on screen)

In part 2 of the experiment, you see three lists with pairs of different lotteries on screen. Lists 1 and 2 each contain 14 pairs of different lotteries, list 3 contains 7 pairs of different lotteries. The pairs of lotteries each differ in payments, not in probabilities for the possible payments. For each of the 35 pairs of lotteries in total, you have to choose either option A or option B.

The payments of the lotteries are given in tokens with 10 tokens = 1 Euro. At the end of the experiment, one of the 35 pairs of lotteries is randomly chosen for payment. The option you have chosen for this pair is carried out. The payment from this lottery is converted to Euro at the end of the experiment and paid to you in cash together with your earnings from the other parts of the experiment.

Part 3 (on screen)

In part 3 of the experiment, you are randomly matched with another participant. In the following we name the other participant "the other person". You do not receive any information about the other person's identity. Conversely, the other person receives no information about your identity.

You and the other person see 24 questions. In each question, you can both choose independently between option A and option B. Each option allocates a certain amount of money in Euro to you and the other person. Your payment is determined by the sum of monetary amounts assigned to you in all 24 questions. You receive the sum of monetary amounts you have allocated to yourself. In addition, you receive the sum of monetary amounts the other person has allocated to you. The other person receives the sum of monetary amounts you allocated to the other person and the sum of monetary amounts they allocated to themselves. This means that your decisions affect both your own payment and the payment of the other person. Likewise, the other person's decisions affect your payment and the payment the other person receives.

For each of the 24 questions, please indicate the option you prefer most. Once you have made your decision, mark the appropriate item and click "OK" to proceed to the next question.

B.2. Comprehension questions (P^H [S^H])

1. Assuming, the following values are given in a period:

	For passing on no information	For passing on information of low-quality	For passing on information of high-quality
Costs for information provision	0.00	2.50	5.00
Bonus payment for information provision	0.00	3.00	3.00
Benefit for the patient [Cost reduction for the specialist] from information provision	0.00	3.00	9.00
Income primary care physician	30.00	30.50	28.00
Income specialist	42.50	42.50 [45.50]	42.50 [51.50]
Total patient benefit	42.50	45.50 [42.50]	51.50 [42.50]

i What would be the costs for information provision for the primary care physician if the primary care physician passes on information of low-quality?
ii What would be the benefit from information provision for the patient [cost reduction from information provision for the specialist] if the primary care physician passes on information of low-quality?
iii What would be the income of the primary care physician if he passes on information of high-quality to the specialist?

Please mark the correct answer in each case:

2. The income of physicians or the benefit of the patient from how many decision periods is paid out?

a The income of physicians or the benefit of the patient from one randomly selected period.
b The sum of the income of physicians or the benefit of the patient from 3 randomly selected periods.
c The sum of the income of physicians or the benefit of the patient from all periods.

3. Participants in the role of a specialist …

a …decide in each period on passing on information.
b …do not make own decisions about the examination and treatment of the patient. The optimal examination and treatment decision is made automatically.
c …decide in each period on the examination and treatment of the patient.

Appendix C. Supplementary tables

Table C.1
Characteristics of subjects in the role of PCPs.

	P^H	P^{CN}	S^H	S^L	P^L
Main characteristics					
Gender: share of females (%)	55	60	60	60	50
Age (Mean, sd)	26.05 (7.10)	24.05 (3.05)	24.35 (5.56)	24.30 (3.54)	23.25 (3.57)
Shape of value function					
Concavity $\hat{\sigma}$ (Mean, sd)	0.79 (0.33)	0.74 (0.42)	0.58 (0.28)	0.66 (0.40)	0.78 (0.34)
Loss aversion $\hat{\lambda}$ (Mean, sd)	3.31 (2.70)	2.65 (2.87)	2.60 (2.02)	3.39 (3.47)	3.74 (3.36)
Social value orientation					
Svo angle (Mean, sd)	20.80 (24.16)	16.43 (16.75)	15.81 (18.06)	14.00 (18.95)	22.73 (18.67)
Share of prosocial subjects (%)	45	55	35	45	50
Self-reported attitudes					
"Are you generally a person who is ... 0 = unwilling to take risks, …, 10 = fully prepared to take risk?" (Mean, sd)	4.45 (2.31)	4.10 (2.13)	4.25 (1.89)	4.15 (2.39)	5.05 (2.50)
"How willing are you to give to good causes without expecting anything in return? 0 = not at all willing to do so, …, 10 = very willing to do so" (Mean, sd)	6.20 (2.46)	6.50 (2.31)	6.10 (2.71)	5.15 (2.64)	6.75 (2.73)
"Would you say that ... 0 = most of the time people are just looking out for themselves, …, 10 = people try to be helpful most of the time?" (Mean, sd)	3.50 (2.16)	2.65 (2.21)	2.80 (2.14)	3.20 (2.24)	3.30 (2.60)
"How similar is the following fictive person to you? It is important to this person to do something for the good of society. 1 = completely similar, …, 6 = not at all similar" (Mean, sd)	3.20 (1.11)	3.15 (1.14)	3.45 (0.83)	3.35 (0.93)	2.65 (1.39)
"Imagine the following situation: Today you unexpectedly received 1,000 Euro. How much of this amount would you donate to a good cause?" (Mean, sd)	126.50 (164.55)	144.00 (152.81)	92.50 (89.38)	145.25 (233.58)	112.75 (120.82)

Note: Summary statistics for characteristics of subjects in the role of PCPs. In the questionnaire at the end of the experiment, subjects are asked about main characteristics and self-reported attitudes. The questions for self-reported attitudes are based on questions included in the German Socio Economic Panel (Dohmen et al., 2011), in the European Values Study (European Values Study, 2015), in the World Values Survey (Inglehart et al., 2014), and in the Global Preference Survey (Falk et al., 2018). Parameters for the shape of the value function are estimated from the pairwise lottery choices (Tanaka et al., 2010) conducted in the second part of the experiment. The social value orientation results from the social value orientation test (Liebrand, 1984; McClintock and Liebrand, 1988) in the third part of the experiment. $N = 20$

Table C.2
Classification from social value orientation test.

	Svo angle	Svo type	
		prosocial	individualistic
$\mathbf{P^H}$	20.804	9	11
$\mathbf{P^{CN}}$	16.434	11	9
$\mathbf{S^H}$	15.807	7	13
$\mathbf{S^L}$	13.999	9	11
$\mathbf{P^L}$	22.731	10	10
Null hypothesis	p-value [a]	p-value [b]	
$P^H = P^{CN}$	0.580	0.752	
$P^H = S^H$	0.680	0.748	
$P^H = P^L$	0.454	0.751	
$S^H = S^L$	0.620	0.748	
$S^L = P^L$	0.093	1.000	

Note: Average angle resulting from decisions in the social value orientation test and number of subjects in the role of primary care physicians who are classified as a specific type based on the angle. For simplicity, we subsume the “altruistic” and “cooperative” type as “prosocial” and the “individualistic” and “competitive” type as “individualistic”. Considering all four types separately leads to similar results. a) Reported p-values result from two-sided Mann–Whitney U-tests. They test the null hypothesis that the svo angles are the same in the respective conditions. b) The p-values result from Fisher’s exact tests. They test the null hypothesis that the number of PCPs who are categorized as a specific svo type is independent of the condition. ($N = 20$)

Table C.3
Effects of γ on information provision in condition P^H for PCPs without $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$ ($N = 6$).

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.033	1.000	+	+	0.017	0.750
1.25 to 2.5	+	+	0.733	0.031	0	–	0.000	–
2.5 to 6.25	0	–	0.000	1.000	0	+	0.050	0.500

Note: Differences in average provision of low and high-quality information between γ_1 and γ_2 for physicians without $\hat{\lambda} > 1$ and $\hat{\sigma} < 1$ ($N = 6$). Reported p-values result from two-sided Wilcoxon matched-pairs signed-rank tests using average values over all κ for subjects. They test the null hypothesis that information provision does not differ between γ_1 and γ_2. The columns “Hyp. L” and “Hyp. NL” summarize predictions from Hypotheses L and NL, respectively.

Table C.4
Effects of γ on information provision for PCPs with different $\hat{\lambda}$ (in P^H).

PCPs with $\hat{\lambda} \leq 2.5$ ($\bar{\hat{\lambda}} = 1.235$,

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.033	0.500	+	+	0.022	0.500
1.25 to 2.5	+	+	0.644	0.004	0	–	0.000	–
2.5 to 6.25	0	–	−0.011	1.000	0	+	0.044	0.250

PCPs with $\hat{\lambda} > 2.5$ ($\bar{\hat{\lambda}} = 5.557$, $\bar{\hat{\sigma}} = 0.592$, $N = 11$)

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.082	0.500	+	+	0.100	0.188
1.25 to 2.5	+	+	0.636	0.004	0	–	−0.100	0.250
2.5 to 6.25	0	–	−0.127	0.062	0	+	0.145	0.031

Note: Differences in average provision of low and high-quality information between γ_1 and γ_2. Reported p-values result from two-sided Wilcoxon matched-pairs signed-rank tests using average values over all κ for subjects. They test the null hypothesis that information provision does not differ between γ_1 and γ_2. The columns “Hyp. L” and “Hyp. NL” summarize predictions from Hypotheses L and NL, respectively.

Table C.5
Effects of γ on information provision for PCPs with different $\hat{\sigma}$ (in P^H).

PCPs with $\hat{\sigma} \leq 0.8$ ($\bar{\hat{\sigma}} = 0.499$, $\bar{\hat{\lambda}} = 3.484$, $N = 10$)

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.080	0.625	+	+	0.090	0.250
1.25 to 2.5	+	+	0.710	0.002	0	−	−0.080	0.500
2.5 to 6.25	0	−	−0.030	0.250	0	+	0.040	0.125

PCPs with $\hat{\sigma} > 0.8$ ($\bar{\hat{\sigma}} = 1.100$, $\bar{\hat{\lambda}} = 2.492$, $N = 10$)

γ_1 to γ_2	Low-quality information				High-quality information			
	Hyp. L	Hyp. NL	Δ	p-value	Hyp. L	Hyp. NL	Δ	p-value
0 to 1.25	0	0	−0.040	0.375	+	+	0.040	0.250
1.25 to 2.5	+	+	0.570	0.008	0	−	−0.030	1.000
2.5 to 6.25	0	−	−0.120	0.188	0	+	0.160	0.062

Note: Differences in average provision of low and high-quality information between γ_1 and γ_2. Reported p-values result from two-sided Wilcoxon matched-pairs signed-rank tests using average values over all κ for subjects. They test the null hypothesis that information provision does not differ between γ_1 and γ_2. The columns "Hyp. L" and "Hyp. NL" summarize predictions from Hypotheses L and NL, respectively.

Table C.6
Information provision.

	N	All		$\gamma = 0$		$\gamma = 1.25$		$\gamma = 2.5$		$\gamma = 6.25$	
		Low	High	Low	High	Low	High	Low	High	Low	High
$\mathbf{P^H}$	20	0.531	0.261	0.175	0.210	0.115	0.275	0.755	0.220	0.680	0.320
$\mathbf{P^{CN}}$	20	0.562	0.213	0.095	0.165	0.275	0.200	0.760	0.205	0.750	0.225
$\mathbf{S^H}$	20	0.607	0.056	0.045	0.020	0.120	0.030	0.815	0.040	0.875	0.110
$\mathbf{S^L}$	20	0.484	0.318	0.095	0.280	0.230	0.260	0.600	0.345	0.635	0.365
$\mathbf{P^L}$	20	0.473	0.355	0.235	0.245	0.315	0.230	0.615	0.350	0.485	0.510

Note: Average share of low-quality and high-quality information provision for specific values of γ.

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Concluding remarks

Concluding remarks

The five studies presented in this thesis provide evidence that information and incentives influence medical decisions. As tight control over the decision environment is necessary to identify pure effects of information and incentives, all five studies use lab experiments to test behavioral conjectures or theoretical predictions. While the first two chapters focus on patients' decisions, the other three chapters concentrate on decisions of physicians. With respect to the influence of communicated information, the results from chapter 4 show that the decision context is important and that transferring results from other contexts does not necessarily lead to correct conclusions. It is therefore important to view the results on how information and incentives influence decisions in the specific context of interest.

Main results

The first two chapters focus on the effect of information on patient decisions. In chapter 1, we study whether information about past events affects the decision to buy or sell insurance. Participants in the experiment know at which position a wheel of fortune stopped in previous rounds, i.e., they know whether the loss (nearly) occurred. Moreover, in two conditions, participants know the buying or selling prices of other participants in past rounds. We observe that participants are willing to pay more for insurance in the market condition after a loss almost happened. Thus, the irrelevant information about past events affects decisions when participants have information about others' preferred prices for the insurance in our experiment. The study presented in chapter 2 investigates whether patients use information about physicians' past provision behavior and information that physicians communicate for their choice of a physician. We find that patients indeed choose physicians who provided higher treatment qualities in previous rounds. Yet, they also value information communicated by physicians and prefer physicians promising a specific treatment quality. When no information about past behavior is available, written messages become even more important for patients' choice. Taken together, the findings from chapters 1 and 2 lead to the first main result of this thesis:

Result 1: *Information about the past and communicated information can influence decisions of subjects in the role of patients – regardless of whether the information should theoretically be relevant for decisions or not.*

Besides the influence of information on patients' decisions, chapter 2 also shows that physicians provide better treatment when treatment decisions are revealed to potential future patients. This reaction may be caused by reputational motivations, e.g. the desire to be perceived as good by patients. Or it could be caused by financial incentives when physicians expect to be chosen more often and thus earn higher profits with higher previous treatment qualities. Chapters 3 and 5 take a closer look at physicians' response to financial incentives. In chapter 3, we investigate how resource scarcity affects physician provision behavior. Physicians receive a capitation payment and decide on the allocation of resources to two patients. Varying the capitation budget between three values, we find that physicians provide a relatively stable share of their budget as services to patients. The change in the capitation budget thus leads to a proportional shift in physicians' profits and patients' outcomes. The study in chapter 5 analyzes whether financial incentives can improve the information flow between physicians. PCPs receive a bonus payment for passing on information of low or high quality to specialists. The experimental results show that PCPs respond to changes in the bonus payment in line with the non-linear version of our model, which takes an aversion to losses from a reference point into account. The provision of low- and high-quality information depends on the size of the bonus payment. The observations made in chapters 3 and 5 underline how important the level of incentives is for outcomes which is summarized in the second main result:

Result 2: *Financial incentives influence behavior of subjects in the role of physicians. Not only does the existence of financial incentives matter, but also the level of incentives is of relevance.*

While chapter 2 shows that information communicated by physicians affects patients' choice of a physician, chapter 4 investigates if communication also influences physicians' decisions. For this purpose, the experiment from chapter 3 is extended with the opportunity for patients to write a message to their physician prior to each decision. The communication opportunity does not affect decisions per se. Not writing a message when given the opportunity is detrimental for patients though. Moreover, message content influences decisions depending on patient type. Physicians' reactions to messages from patients are similar to patients' reactions to physician messages in chapter 2. The findings from both chapters lead to the third main result of this thesis:

Result 3: *Communicated information affects decisions of subjects in the role of patients and physicians. Given the opportunity to write a message, remaining silent is particularly detrimental for senders.*

Future research

Although an abstract framing can lead to other perceptions of the decision task than intended (Harrison & List, 2008), chapter 1 uses, nevertheless, a neutral framing. It is not clear if we had observed the same decision pattern under a medical framing. In order to be sure, future experiments should be conducted with a medical framing. For patients' choice of insurance, experiments could build on our finding that a loss which almost happened influences decisions. An interesting research question would be if the effect of such a near-loss from healthcare costs on the willingness to pay for insurance is similar when it happened to relatives or friends instead of to oneself in the past. The influence of information should furthermore be studied with respect to other decisions of patients. For patients' choice of a physician, the experiment from chapter 2 could be extended with other reputation information. Physicians' past behavior could be distorted, for example by a random variable or by subjective evaluations of patients.[1]

The findings from chapters 3 and 5 complement studies demonstrating that financial incentives affect physician behavior in other settings (e.g., Brosig-Koch, Hennig-Schmidt, Kairies-Schwarz, & Wiesen, 2017; Brosig-Koch, Henning-Schmidt, Kairies-Schwarz, Kokot, & Wiesen, 2019; Hennig-Schmidt, Selten, & Wiesen, 2011). These studies typically implement passive patients accepting any medical treatment provided. In order to approach a more complex decision environment, future research could weaken this assumption and allow for more interaction between patients and physicians. When subjects in the role of patients are in the lab, a more realistic setting than in chapters 2, 3, and 4 could be achieved by giving them less information about their benefit functions. In reality patients usually do not know for sure the exact benefit from the range of treatment options, but may have some information about how medical treatments tend to affect them. This could be reflected in experiments by informing patients only about certain aspects of their health characteristics and not the full benefit functions, for example.

Chapters 2 and 4 provide evidence that communicated information influences medical decision making. Although the opportunity to communicate does not affect outcomes on average, patients and physicians respond to empty messages and particular message contents. However, both studies can only offer first insights on effects of communicated information. For a better understanding, future research should investigate patient-physician-communication and its influence on treatment decisions and patient benefits further. As both chapters employ one-

[1] Angerer, Glätzle-Rützle, Rittmannsberger, and Waibel (2021) test how reputation in the form of a subjective rating by patients influences physician decisions. In their experiment, physicians charge patients a price though, while we assume that patients' costs are covered by insurance in chapter 2.

sided communication, it would be useful to test how forms of two-sided communication like an open chat or video communication influence medical decisions. With two-way-communication the social distance between patients and physicians may be smaller. As a consequence, physicians may be more influenced by information communicated by patients or feel more obliged to provide higher benefits to their patients.

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Attachments