Personalized Medicine: Legal and Econmic Analyses in a Fast-Changing Field

Physicians' Incentives to Adopt Personalized Medicine: Experimental Evidence

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Introduction

- Personalized medicine (PM) implies profiling of patients to determine treatments or medical interventions according to their best predicted response.

- **Advantage of PM information**: It allows the physician to achieve a better match between therapeutic choice and patients.

- In particular, PM uses information coming from genetic testing in the process of diagnosis and treatment.

Introduction

- We still observe very low take-up rates of genetic tests.

- Better allocating treatments among patients is a promising way to reduce both health expenditure and adverse consequences of treatments (Nimmesgern *et al.*, 2017).

- When personalized medicine information is available (even on a free basis), physicians tend to under-use it (Howard *et al.*, 2017).

Introduction

- **Several reasons**:
  - Uncertainty around this ongoing new technology!
  - Adoption of new technology/knowledge is time demanding.
  - Payment schemes at work do not provide incentives.

- **Aim of this article**: focus on the interplay between the two last issues.

Objective of this research

- We explore how physicians' payment schemes affect their incentives to use personalized medicine techniques.
- Also to what extent the use of these techniques benefit patients.
- New technology $\Rightarrow$ Few data available!
- We performed an experiment to replicate physicians' trade-off:
  - Update is time demanding at the beginning;
  - Allows physicians to be more efficient.

Related literature

- Literature on **incentives in physician payments** (From Ellis and McGuire, 1986 to Mak, 2017): Incentives matter, but not only!

- Literature on **physicians' decisions to adopt personalized medicine techniques** (Garrison and Towse, 2014; Dinan *et al.*, 2015; Howard *et al.*, 2017): Physicians under-use personalized medicine even if it is free.

- Literature on the use of **experiments in health economics** (Henning-Schmidt *et al.*, 2011; Green, 2014; Lagarde and Blaauw, 2017): Subject pool matters.

Experiment design

- Two ways of measuring effort in the lab:
  - "**Chosen effort tasks**" experiments: effort is "hypothetical" because declarative and proxied by a cost function.
  - "**Real effort tasks**": effort is inferred based on behaviours observed on a real task.
- In health economics, experimenters have used both methods.
- We chose the second option.

Experiment design

- Design inspired by Green (2014, JEBO).
- Two actors:
  - A "**downstream principal**": the patient (Subject 1) who highlights words that he thinks are wrong in texts.
  - The **agent**: the physician (Subject 2) who provides proofreading assistance.
- A 2-step game: (i) highlight and (ii) correction of words.
- Aim of Green's experiment: Study incentive properties of physician payments using a real effort task.

Experiment design

- **Version 2.0 of the game**: we add the personalized medicine dimension to analyze its effect.
- In step 1: we have real subjects in a "passive" role (they are referred to as patients for Step 2).
- In step 2 (the main step): the physician provides proofreading assistance on texts.
- PM introduced as the possibility for subject 2 to have access to **priority sentences** (the area where corrections are likely to maximize patient benefit).
- Only corrections done in priority sentences are taken into consideration to compute gains of subject 1.

Periods of the game

- In each treatment the game is run on 3 periods.
- In each period, each subject can proofread up to 8 dictations (24 per "treatment") and participate to 2 treatments (within-design).
- **Period 1**: 8 dictations presented without showing priority sentences: PM does not exist in this situation.
- **Period 2**: 8 dictations presented with priority sentences underlined: PM is freely accessible.
- **Period 3**: the subject first has 1 minute to decide between a file of 8 dictations with priority sentences underlined (personalized medicine) and a file of dictations with no information (no PM); then proofreading work starts.

Proofreading in period 1

Il est inexplicable que nous soyons vivant. Je remonte ma lampe électrique à la main, les traces de l'avion sur le sol. A deux cent cinquante mètres de son point d'arrêt nous retrouvons déjà des ferrailles tordues et des tôles dont, tout le long de son parcours, il a éclaboussé le sable, […]

L'avion sans culbuté, a fait son chemin sur le ventre avec une colère et des mouvements de queue de reptile. A deux cent soixante-dix kilomètre-heure il a rampé. Nous devons sans doute notre vie à ces pierres noires et rondes qui roulent librement sur le sable et qui ont formé plateau à billes.

Proofreading in period 2

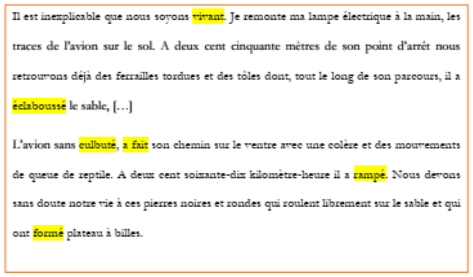
J'admirais lentement ressortir de mille trous, de milles anfractuosités du roc, tout ce que mon approche avait fait fuir. Tout se mettait à respirer, à palpiter ; le roc même semblait prendre vie et ce qu'on croyait inerte commençait timidement à se mouvoir, des êtres translucides, bizarres, aux allures fantasques, surgissaient d'entre le laxis des algues ; l'eau se peuplait ; le sable clair qui tapissait le fond, par places s'agitait et, tout au bout de tubes ternes qu'on eût pris pour de vieilles tiges de jonc, on voyait une frêle corolle, craintive encore un peu, par petits soubresauts s'épanouir.

Un novice des choses de l'Alpe eût été surpris de constater la légèreté, contrastant avec la lourdeur générale de leur allure, avec laquelle les deux montagnards posaient le pieds sur les cailloux effrités du chemin. Aucune pierre ne roulait et les clous mordaient la terre avec ensemble, donnant l'impression d'une totale adhérence.

Period 3 of the game

- The subject takes one minute to make a choice between set (a) and set (b) of 8 dictations.
- In set (b), 0.50 euro is taken away from final gains, for each dictation treated.

(a) Dictation like in Period 1



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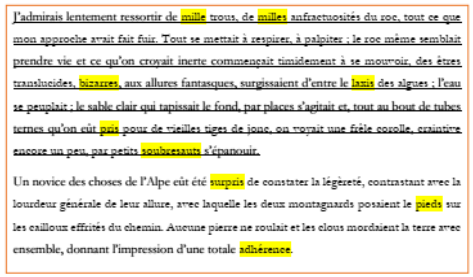
(b) Dictation like in Period 2



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Payment systems that we study (our treatments)

- **FFS**: 0.30 euro per intervention, regardless of its quality.
- **CAP**: Payment per proofreading: 1.75 euro per proofreading.
- **P4P**: Payment based on the quality of the intervention:
  - 2.50 euros if 80% of the words in priority sentences are correct;
  - 0 euro otherwise.
- **Cost of PM for subject-2**: If the decision is to have access to priority sentences, 0.50 euro is deduced from final gains for each treated proofreading.

Table 3: Correspondence between experimental and real-life personalized medicine settings

	In experimental setting	In real-life setting
Baseline: Period 1 – similar to Green (2014)'s experiment	Crude declaration of wrong words by subject-1 & priority sentences not shown	Crude declaration of symptoms by patient & subset of relevant symptoms not shown
Period 2: *PM free*	Priority sentence shown, physician can target/focus interventions	Subset of relevant symptoms shown, physician can target/focus interventions
Period 3: *PM bought and voluntary*	Are you willing to buy the information on priority sentences?	Are you willing to buy (/spend time on obtaining) personalized medicine information?
Payment schemes	-% quality of overall text -per intervention -per text	-P4P -FFS -Capitation

Reformulation of the objectives

- How do the different payment schemes affect the decision to adopt personalized medicine?

- What is the impact of personalized medicine on physicians' outcome variables?
  - Impact on the rate of useless actions?
  - Impact on the rate of well-treated patients (proofreadings)?

Identification strategies

- **When access to information is free** $\rightarrow$ a panel linear model.
- **When access to information is costly** $\rightarrow$ an IV-Probit model (see next slide).

Identification strategies

- Access to PM is free:

$$y_{i,T} = c + \alpha_i + \beta Pay_{iT} + \gamma INFO_{iT} + \theta Pay_{iT} * INFO_{iT} + \Theta X_i + \epsilon_{iT}$$

- Access to PM is costly:

$$\begin{aligned} BUYINFO_{i_T} &= c + \mu Pay_{iT} + \upsilon TECHNO_i + \rho X_i + \upsilon_{iT,} \\ y_{i,T} &= c + \alpha_i + \beta Pay_{iT} + \gamma \widehat{BUYINFO}_{iT} + \theta Pay_{iT} * \widehat{BUYINFO}_{iT} \\ &\quad + \Theta X_i + \epsilon_{iT} \end{aligned}$$

Instrument: Techno

- There is a statistically significant link between appetite for innovative technologies (TECHNO) and decision to invest in PM.

- The instrument is not weak (Fisher test) and the IV model is more consistent than an OLS model for all our dependent variables (Wu-Hausman test).

	Dependent variables :		
	Number of actions	**Rate of useless actions**	**Rate of well treated patients**
PM	-45.327*** (8.910)	-0.761*** (0.125)	0.266*** (0.098)
Constant	36.348*** (4.023)	0.542*** (0.056)	0.305*** (0.044)
Observations	190	190	190
Weak instruments (df1/df2)	7.604***	7.604***	7.604***
Wu-Hausman	50.384***	43.239***	5.688**
Note :	*p<0.1 ; **p<0.05 ; ***p<0.01		

Decision to buy PM and payment schemes

Table: Decision to buy information and payment mechanisms

Payment system	P4P	FFS	CAP	Total of decisions
Decisions				
Buy	55	9	13	77
Not buy	40	40	33	113
Total number of subjects	95	49	46	190

p-value = 4.236e-06

Table: Variables affecting the decision to buy the information on priority sentences

Dependent variable: decision to invest in the information on priority sentences	
Model: Probit model	
FFS (Ref: P4P)	-1.072*** (0.254)
CAP (Ref: P4P)	-0.919*** (0.247)
TECHNO Strongly	0.606** (0.266)
Weakly	0.838* (0.450)
Controls included?	*Yes*
Constant	-2.526 (1.610)
Observations	190
Log Likelihood	-110.488
Akaike Inf. Crit	238.976
Note:	*p<0.1; **p<0.05; ***p<0.01

Variables affecting the decision to buy PM

- There is not independence between the payment mechanism and the decision to buy PM.
- P4P is more likely (compared to FFS and CAP) to be associated with a purchase decision.
- Another argument for TECHNO as our instrument.

Table: Impact of free information and payment mechanisms on the rate of interventions outside of priority sentences

	Dependent variable: Rate of interventions outside of priority sentences. Model: Random effect panel linear model		
	(1)	(2)	(3)
FFS (Ref: P4P)	0.341***(0.036)	0.303***(0.046)	0.371***(0.056)
CAP (Ref: P4P)	-0.039(0.035)	-0.048(0.036)	-0.081*(0.047)
INFO (Ref: No info)	-0.244***(0.026)	-0.244***(0.026)	-0.227***(0.036)
Controls included?	*No*	*Yes*	*Yes*
INFO in the FFS payment system			-0.136**(0.061)
INFO in the CAP payment system			0.067(0.060)
Constant	0.284***(0.025)	0.511*(0.289)	0.503*(0.290)
Observations	190	190	190
R^2	0.522	0.528	0.550
Adjusted R^2	0.514	0.510	0.527
F Statistic	67.651*** (df = 3; 186)	29.130*** (df = 7; 182)	24.408*** (df = 9; 180)
Note:	*p<0.1; **p<0.05; ***p<0.01		

Table: Impact of free information and payment mechanisms on the rate of well corrected dictations

	Dependent variable: rate of well treated dictations	
	Model: Random effect linear panel model	
	(1)	(2)
FFS (Ref: P4P)	-0.297*** (0.048)	-0.263*** (0.062)
CAP (Ref: P4P)	-0.083 (0.047)	-0.073 (0.048)
INFO (Ref: No info)	0.03 (0.027)	0.003 (0.027)
Controls included?	*No*	*Yes*
Constant	0.536*** (0.031)	0.130 (0.383)
Observations	190	190
R^2	0.174	0.187
Adjusted R^2	0.160	0.156
F Statistic	13.018*** (df = 3; 186)	5.992*** (df = 7; 182)

*p<0.1; **p<0.05; ***p<0.0

Interaction between information and the payment system was not included because it was not significant.

Free access to PM and rate of well-treated proof-reading

- Giving a free access to PM information decreases the rate of useless actions (interventions done on non-priority words).

- The interaction between free PM and payment mechanism is higher in FFS for the variable "rate of useless actions".

- A free access to PM seems to be non-associated with the rate of well-treated dictations (it is positive but not statistically significant).

- The interaction between P4P and free access to PM is not significant as one would have expected.

Table: Impact of costly information and payment mechanisms on the rate of interventions outside of priority sentence

	Dependent variable: Rate of interventions outside of priority sentences		
	Model: IV-Probit panel model		
	(1)	(2)	(3)
FFS (Ref: P4P)	0.338*** (0.068)	0.292*** (0.077)	0.653*** (0.123)
CAP (Ref: P4P)	-0.038 (0.057)	-0.078 (0.069)	0.130 (0.144)
BUYINFO (Ref: Non-buyers)	-0.280* (0.143)	-0.403** (0.179)	-0.146 (0.194)
Controls included?	No	Yes	Yes
BUYINFO in the FFS payment system			-1.414** (0.386)
BUYINFO in the CAP payment system			-0.477 (0.376)
Constant	0.269*** (0.086)	0.152 (0.242)	-0.100 (0.245)
Observations	190	190	190
R^2	0.468	0.487	0.523
Adjusted R^2	0.460	0.467	0.500
Residual Std. Error	0.208 (df = 186)	0.207 (df = 182)	0.200 (df = 180)
F Statistic	54.637*** (df = 3; 186)	24.686*** (df = 7; 182)	21.970*** (df = 9; 180)

Table: Impact of costly information and payment mechanisms on the rate of well treated over treated dictations

	Dependent variable: Rate of well treated over treated dictations
	Model: IV-Probit panel model
FFS (Ref: P4P)	0.001 (0.089)
CAP (Ref: P4P)	0.121 (0.079)
BUYINFO (Ref: Non-buyers)	0.391* (0.206)
Controls included?	Yes
Constant	-0.187 (0.278)
Observations	190
R^2	0.147
Adjusted R^2	0.114
Residual Std. Error (df = 182)	0.237
F Statistic (df = 7; 182)	4.482***
Note:	*p<0.1; **p<0.05; ***p<0.01

This table is the second-step regression. See the first step in Result 1. Interactions are not shown because they are not significant.

Costly access to PM and rate ofwell-treated proof-readings

- Giving a costly access to PM information decreases the rate of useless actions (interventions done on non-priority words).

- The interaction between costly information and payment mechanism is higher in FFS for the variable "rate of useless actions".

- A costly access to PM is associated with a positive impact on the rate of well-treated proofreadings.

Messages to take away

- Compared to FFS and CAP, P4P scheme is an important driver in the decision to adopt PM.
- Although expected to clearly dominate the other schemes, P4P is NOT efficient in transforming a free access to PM in a substantial qualitative outcome for patients.
- When accessible on a costly basis, PM is positively associated to quality.
- It suggests that subjects tend to better use information when they paid for it $\rightarrow$ phenomenon of commitment device.