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Armenak Antinyan
Cardiff University and Zhongnan University

Stefania Bellio
Azienda Zero

Marco Bertoni
University of Padova, HEDG and IZA

Luca Corazzini
University of Venezia "Ca' Foscari" and HEDG

Elena Narne
Azienda Zero

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Digital Access to Healthcare Services and Healthcare Utilization: A Quasi-Experiment

An Italian region introduced a web portal allowing women to manage online their appointment in the public cervical cancer screening program, besides the standard possibility of doing it via phone. We report quasi-experimental evidence on how access to the portal changes screening behaviour. We find that eligible women do manage their appointment online. The introduction of the portal also reduces attendance of the screening program. Two factors contribute to explain this finding. First, by encouraging women not to take a screening test if they performed an analogous one in the previous three years, the portal reduces overly-frequent screening. Second, the portal induces procrastination in rescheduling the appointment. We also find that, when they cancel their appointment online, women are more likely to share information about their screening episodes in the private health sector, that is useful to schedule future screening appointments.

JEL Classification: H51, O33, I12, D91

Keywords: ICT intervention, cervical cancer, screening uptake, quasi-experiment

Corresponding author:
Marco Bertoni
Department of Economics and Management
University of Padova
via del Santo 33
35123 Padova
Italy
E-mail: marco.bertoni@unipd.it

1. Introduction

The digital world is becoming a crucial pillar of the effective functioning of societies (Hodson, 2018). For example, the rise of information and communication technologies (ICT henceforth) allows governments to provide a variety of digital services which can enhance the efficiency and the accountability of public institutions, facilitate information transmission between administrative offices and citizens, and results in substantial economic benefits for the public sector and citizens alike (Faulkner et al., 2019).

The digital transformation of services has interested the healthcare sector as well, considerably influencing healthcare provision and health systems in general (Ricciardi et al., 2019). A growing body of scientific literature tries to assess the impact of ICT innovations on the effectiveness, accessibility, and resilience of the healthcare systems (e.g., Agarwal et al., 2010; Marques and Ferreira, 2020; Kraus et al., 2021).

A distinctive feature of the ICT innovations analysed by most of the literature is that patients do not have a proactive role when interacting with these technologies. These innovations concern platforms that are actively used by the administrations of medical institutions for better management practices (e.g., Chaudhry et al., 2007), computerized systems that send reminders to patients to promote various types of health behaviour (e.g., Ruffin et al, 2007; DeFrank et al., 2009, Vidal et al., 2014), interactive web-pages providing information to the patients (e.g., Ruffin et al., 2007; Elkin et al., 2017), and platforms that allow the patients to access their test results (e.g., Goldzweig et al., 2017). Some studies (e.g., Goldzweig et al., 2017) also investigate the impact of complex ICT innovations that combine several of these functionalities.

Unlike the cases discussed above, in this paper we assess the impact of a newly introduced digital technology in which patients have a proactive role. More specifically, we report quasi-experimental evidence from a North-eastern Italian local health unit (LHU henceforth) that gradually introduced a user-friendly web portal within the national cervical cancer screening program allowing women in the program to autonomously modify (either reschedule or cancel) their reserved cancer screening appointment, pre-assigned by the LHU. The intervention targets roughly 1,600 women invited for screening in four of the LHU's screening centres between November 2019 and January 2020.

In order to assess the causal effect of the web portal, four screening centres operating within the geographical area of the LHU were considered. The four screening centres were divided into two treatment groups that presented no ex-ante differences in screening take up trends during the two years before the intervention, and were randomly allocated to serve as:

i) The control "phone only" group. Women in this group received a screening invitation letter with a pre-specified slot and no information about the web portal. Following the status-quo, if women in this group wanted to modify their appointments, the letter instructed them to call the telephone number of the phone service run by the LHU to manage appointments within the opening hours of the service.

ii) The treated "web or phone" group, whose members received a screening invitation letter with a pre-specified slot and detailed information on how to modify the appointment through either the newly introduced web portal or the standard phone service.

The analysis is based on anonymized administrative data from the LHU's own records, that contain information on participants' screening outcomes in the current and the previous invitations to screen within the national screening program. We employ a difference-in-differences design and compare the changes in several screening outcomes across the current and the previous invitation rounds for women in the treated and control groups. Identification of causal effects in the difference-in-differences design relies on a parallel trends assumption, that we are able to test with the data at hand for the invitation rounds before the intervention took place, and on the absence of group-specific shocks whose timing coincides with the intervention. The homogeneous nature of the target population, which resides in a set of neighbouring municipalities, as well as the identical and highly controlled institutional setup faced by both groups corroborate the validity of this assumption.

First, we assess whether the web portal was effectively used by women to reschedule their appointments. This is not a trivial question, given that the uptake of digital services is rather low and governments struggle to make citizens use these services (Castelo et al, 2015). For example, according to Eurostat, in 2019 only 55% of the EU population used online interfaces for interacting with the public authorities. When it comes to obtaining information from websites of public institutions, sending or downloading forms through the Internet, this percentage shrinks further

Second, we investigate whether the introduction of the web platform affects the participation in the screening program. Providing women with an alternative digital solution to reschedule the date of the screening slot represents a nudge that, without altering incentives or precluding other possibilities, can weaken the behavioural obstacles to cancer screening (e.g., Benartzi et al., 2017).[1] For instance, phone aversion – the tendency of individuals to shy away from phone conversations – is a common individual response to social interactions (LaRose, 1999; Rettie, 2007) and can act as a

[1] Nudges are proven to be potent catalysts of human behavior in such important domains as health (Milkman et al., 2011; Altmann and Traxler, 2014), finance (Cadena and Schoar, 2011; Karlan et al., 2016), education (Benhassine et al, 2015) among others.

barrier to rescheduling appointments. Phone-averse women who receive a pre-specified slot for cervical cancer screening and cannot make it on that date may be reluctant to call the phone service to reschedule the appointment. As a result, these women may miss the screening slot, which has a negative effect on cancer prevention and is costly for the healthcare system (e.g., Hallsworth et al, 2015; Berliner Senderey et al, 2020). Nonetheless, if given the opportunity to reschedule the appointments online, phone averse women may benefit from this chance and attend the screening.

Third, we also study whether the introduction of the portal increases the ability of the LHU to collect more precise information on women's screening behaviour outside the national screening program. In fact, the web portal asks women who do not intend to participate in the program to inform the LHU about the main reason for that. One option that women can select is to have already done a test outside the public screening program. In the portal, emphasis was posed to communicate to the women that some information about the previous exams, like the date of their last screening test, can help the health system to correctly schedule their future appointment.

Moving to the results, we document positive effects of the web portal on the organizational efficiency of the LHU. While the probability of handling (that is, moving or cancelling) appointments during the intervention period is similar across the two treatment groups, women in the "web or phone" group are substantially less likely to handle appointments by phone – this probability declines by around 18 percentage points, or by 50% of the control group mean. Moreover, we also find that the web portal facilitates the women' engagement in the transmission of some general information to the LHU. Women with access to the portal are more likely to report the personal reasons for an eventual appointment cancellation and the date of their last screening (this probability moves from 1.9 percentage points in the control group to 6.3 in the treatment one, a very large effect in relative terms).

Surprisingly, despite the positive effects of the platform on the organizational efficiency of the LHU, and in contrast to the intuitive prediction that providing a further digital instrument to reschedule screening slots should promote the adherence to the public screening program, we find that the introduction of the web portal leads to a reduction of participation in this program. More specifically, giving access to the web portal decreases the probability of attending the screening by roughly 15 percentage points, or by 30% of the control group mean. This decrease is mirrored by an increase in the probability of unjustified absences at the screening appointment by 10 percentage points, or by 30% of the control group mean, and by an increase in the probability of cancellations (i.e., justified absences) of 6 percentage points (30% of the control group mean). We conjecture that the increase in cancellations is likely happening because the portal enhances into women the

awareness that they do not need to repeat the screening if they have already undertaken a test over the last three years, thus reducing overly-frequent screening. Moreover, the portal offers to the women a more accessible channel to communicate information about their previous screening. The increase in no-shows could instead be due to the fact that the web portal increases the number of females who can procrastinate in rescheduling their appointments (Akerlof, 1991; Rabin, 1998; Ariely & Wertenbroch, 2002) and eventually miss the screening.

Our paper contributes to the nascent literature on digitalization in healthcare by providing causal evidence on the impact of an online system that patients can use to reschedule appointments for health screenings. To the best of our knowledge, previous contributions consider multidimensional ICT interventions that were either targeted to health practitioners – not to patients – or simultaneously combine the introduction of web-based systems, organizational changes or different communication strategies to contact patients (Chaudhry, 2007; Vidal et al., 2014; Oscarsson, Wijma & Benzein, 2008), making it hard to pin down the effect of each dimension.

A relevant example in this direction is Chaudhry et al. (2007). This paper shows that the introduction of a web-based system designed to help secretaries manage appointments for breast cancer mammography increases the screening rate from 55.3% in the control group to 64.3% in the treated group. Unlike in Chaudhry et al. (2007), the web application considered in our study is directly accessed by the women enrolled in the screening program. In addition, their manipulation also involves the introduction of invitation letters for mammography screening, as women in their study are not part of an organized screening program. Instead, we work with a sample of women who are already part of a screening program, and the web portal only manipulates the way in which they can manage their appointment.

Another example is Vidal et al. (2014). They introduce a system that sends SMS reminders 3 days before women's breast cancer screening appointment, stating also that women can change their appointment by replying to the SMS. In that case, a second SMS with a new pre-assigned appointment is sent automatically. This SMS system increases the screening rate from 65% in the control group to 74.9% in the treated group. However, the participation of women who reschedule their appointment does not increase, as the automated SMS does not offer the possibility of choosing the new screening appointment. Our study differs from Vidal et al. (2014) because the intervention we analyse only manipulates the way in which women handle their appointment. In addition, SMS reminders are sent a few days before the appointment to women in both groups.

The rest of the paper unfolds as follows. Section 2 discusses the institutional setting. Section 3 illustrates the quasi-experiment. We present the data in Section 4, the empirical methods in Section 5, and the results in Section 6. Section 7 proposes a possible behavioural explanation to rationalize the main results. Concluding remarks follow thereafter.

2. Institutional setting

Cervical cancer is the fourth most common cancer in women globally, affecting roughly 570,000 women and causing the death of 311,000 in 2018. The age-standardized incidence and mortality rate for cervical cancer are strongly correlated with countries' human development level. For instance, these values range between 40.1/100.000 women and 30.0/100.000 women for Eastern Africa, and 6.8/100.000 women and 2.1/100.000 women for Western Europe (Arbyn et al., 2019). The key reason behind this gap lies in countries' differential possibilities to organize effective preventive measures like organized screening and vaccine interventions, that are much more common in developed countries. These programs are very effective in controlling the disease because cervical cancer has a mono-causal genesis: infections from Human Papilloma Viruses (HPV hereafter) are responsible for 99% of all cervical cancer cases (Bosch & de Sanjose, 2003), and the long time period (10-15 years) incurring between the HPV infection, the eventual development of early-stage pre-cancerous lesions, and the final development of invasive cancers allows early diagnosis and treatment. The deployment of HPV vaccination programs is now also helping to eliminate cervical cancer (Brisson et al., 2020).

Since 2003 the European Union recommends that cancer screening should be offered on a population basis in organised programmes (Antilla et al., 2004, European Council, 2003), with quality assurance at all levels. In Italy, the implementation of organised cervical screening programs within each region has been recommended since 1996 (Cappelli et al., 2018, Ronco et al., 2015) and included in the Ministry of Health's "Essential Health Interventions" list since 2001. The management of the National cancer screening program is handled by the 20 Italian Regional health authorities, following national guidelines. Regions are further organised in local health units that cover smaller geographical areas (akin to provinces) and take care of the local implementation of the program, according to the regional organization, by delivering invitations, handling appointments and managing the screening operations within dedicated screening centres. Women are automatically linked to screening centres on the basis of their municipality of residence.

The quasi-experiment we analyse was carried out by a LHU located in North-Eastern Italy. For privacy reasons, we have to anonymise all the information on the LHU. The cervical cancer screening program has been in place in this LHU since 1996, has population-level coverage and targets women aged 25 to 64.[2] Actual coverage is above 80 percent, and average screening take-up is around 65 percent once valid reasons for exclusion (recent test undertaken outside the program, pregnancy status, health conditions) are taken into account. Women aged 25-29 are offered to take a PAP smear every three years while women aged 30-65 are offered to take a HPV test every five years.

In case of a positive outcome of the test, women undergo a cytological test. If this is also positive, women are invited to undertake a colposcopy. All these steps are covered by the National Health System. In addition, women who receive a diagnosis of neoplasm exit from the screening program.

Within the program, women receive by regular mail closed-date invitations at regular intervals dictated by the program rules. Invitations are scheduled 3 years after a missed invitation, 3 years after a PAP test, 5 years after a HPV test, and 1.5 years after a cancelled invitation for pregnancy. Screening slots are allocated to women on a monthly basis, and the available time slots are randomly allocated among women eligible to screen within a given month. A SMS message reminds women about their appointment a few days before the scheduled date.

Women who want to move their appointment or wish to cancel it can do it via phone. Cancellations can take place for the following reasons:

- having already undertaken a PAP or HPV test in the last three years in a private facility or within the public sector following a GP or gynaecologist prescription. In this case, both the phone operator and the web portal ask women whether they can recall the date of the test or not. This is important for planning the following appointment according with the guidelines of the program.
- pregnancy;
- other health reasons;
- general willingness to drop-out from the screening programme, without giving any reason.

[2] A complementary program for HPV vaccinations of women aged 12 is in place since 2008 and involves all women born for 1996 onwards. Consistently with the diffusion of the HPV vaccination, the cervical screening programme has been rescheduled for HPV-vaccinated women that were vaccinated with two doses by age 15. For these women, the first screening appointment is planned at age 30 (instead of age 25). This change took place in 2021.

On top of reporting basic information on the screening program as well as the date and location of the appointment, the invitation letter reports the phone number of the admin team that manages appointments and the working hours of the service (Monday to Friday, 10.30am-1.30pm).

3. The Quasi-Experiment

We report the results of a quasi-experiment carried out by our partner LHU, aimed at assessing the effectiveness of a web portal that works alongside the phone service and allows women to manage appointments by themselves. The intervention targets women invited for a cervical cancer screening within the program between November 2019 and January 2020. This population was divided in two groups:

i) the "phone only" control group only has access to the phone service to manage appointments. For this group everything works as in the business-as-usual setting described in Section 2. The web portal is not accessible to this group, and neither is this group formally aware of the existence of the web portal.

ii) the "web or phone" treatment group has access to both the phone service and the web portal. The invitation letter informs women about the possibility to use the portal, introduces its functions, includes the web address of the portal and the login credentials of the recipients. A leaflet informing women about the advantages of the portal in terms of flexibility and autonomy in managing their appointment is printed on the back side of the invitation letter.[3]

In the absence of any feasibility constraint, the ideal experimental design would have entailed individual-level random assignment of women to treatment groups. Unfortunately, it was not feasible for the LHU to deliver different letter types to single individuals, and an alternative route had to be followed. As discussed above, the LHU has several different screening centres, four of which are involved in this program. Letters for each screening centre are prepared and dispatched in separate batches. The solution adopted to generate variability in treatment status was to dispatch different letters to women affiliated with different screening centres.

Given the very small number of centres – four in total – it was not feasible to run a clustered randomized trial because small sample bias could have easily led to randomization failure. The adoption of a Difference-in-Differences (DiD) design was preferred, and screening centres were allocated to different treatment groups in such a way that trends in screening take-up across the two groups for the periods November 2018-January 2019 vs. November 2017-January 2018 were

[3] The invitation letters used in "web or phone" and "phone only" as well as the leaflet used in "web or phone" are included in the appendix.

comparable. The treatment received by each of the groups was then randomly assigned. The resulting allocation is depicted in Appendix Table A1.

Importantly, the DiD design discussed above is different from the one we adopt in our main analysis, presented in Section 5 below. Initially, the intervention was designed with the screening centres being the statistical unit of interest. This was done because aggregate data on take-up by month and screening centre were the only pieces of information available to the LHU at the time of allocating the centres to groups. After the intervention was carried out, we were instead granted access to individual-level anonymised data only for the subjects that were invited to screen during the intervention (i.e. between November 2019 and January 2020). However, this does not permit us to reconstruct screening outcomes for women invited in each screening centre in the same month of previous years, because individual screening invitations happen at much lower frequency (see Section 2). As a result – as described in greater detail in Section 5 – our empirical strategy had to change, and we moved to the comparison of outcomes by treatment groups for the current and past invitations of the subjects involved in the intervention. This implies that, with respect to the original plans, we compare invitations that are farther apart in time (3/5 years w.r.t. 1 year). Rather reassuringly, in Section 6 we show that this setup delivers parallel trends on the various outcomes we consider even when we use this different strategy.

4. The data

The data come from the administrative archives of our partner LHU. All data were anonymised for analysis outside the LHU, and no personal detail that could permit identification of patient was available to us. For each woman invited to screen during the intervention (i.e. between November 2019 and January 2020*)*, we gathered information on the month and year of birth, the screening centre of reference (and hence treatment status), the date of invitation to screen within the intervention, the type of test proposed (PAP or HPV), and the outcome of the invitation. This is coded as follows:

- Screened: the woman participates in the program.
- No-show: the woman does not participate in the program and does not inform the LHU about her absence. Importantly, the screening program had to be stopped on March 1st, 2020, because of the COVID-19 pandemic, and all women who did not take part in the program or did not communicate their absence by that date are recorded as no-shows.
- Cancelled slot: the woman informs the LHU that she will not participate. Cancellation can be communicated both over the phone and via the web portal, and can take place for the reasons listed in Section 2. The portal asks women to indicate the reason for cancelling, and

if they have carried out a recent test, they are also invited to report the date of the test in order to correctly schedule the next invitations.

In addition, we know whether the appointments were moved or cancelled and whether the rescheduling or cancellation took place via phone or the portal.

We also gained access to the screening history of women in the intervention. For each previous invitation, we know the invitation year, the type of test proposed (PAP or HPV), the outcome of the invitation (coded as above) and whether the appointment was handled (moved or cancelled) by women.

The initial sample consists of 5,642 invitations for 1,659 women aged 25-65 residing in the 20 municipalities related with the four screening centres of our partner LHU where the intervention took place. These women were invited for a cervical cancer screening between November 2019 and January 2020.

Since we use a difference-in-differences design, to estimate treatment effects and test for parallel trends in the pre-intervention period we need at least three invitation rounds – the current one and two pre-intervention ones (see Autor et al., 2003). The number of pre-intervention invitations observed for each woman depends on age – since the program invites only women aged 25-64 – and the timing of arrival within the boundaries of the LHU – as we only observe invitations from our partner LHU. In the final sample, we observe two or more pre-intervention invitations for roughly 75% of invitees, and 3 or more for only 50%. Hence, data for the third-to-last invitation (or previous ones) are only available for a selected share of the target population.

In addition, given that the program invites women aged between 25 and 64 and that we only know the screening history of women invited within the intervention, carried out between November 2019 and January 2020, the support on age that we observe for previous invitations is not full. In particular, we do not observe women older than 61, 58, and 53 in the first-, second-, and third-to-last invitation, respectively. This happens because these older women were not any longer eligible for screening in 2019 and hence are not part of the sample.

In order to minimize the loss of observations and of common support for age that would be related with selecting a longer pre-intervention period, we limit the analysis to the current invitation and up to two pre-intervention ones, and to the common age range 25-58. This leads us to retain 4,167 invitations for 1,649 women. We are also forced to drop close to 100 invitations of women in the control group invited during the intervention period whose appointment had to be cancelled and

postponed because the health professional in charge of doing the test was sick on three screening sessions, as well as roughly 60 invitations for whom the outcome is missing.

As a result of these sample selection criteria, the final sample is composed of 4,003 invitations for 1,638 women. In total, 1,005 women (61% of the sample) are observed 3 times, 355 (22%) are observed twice, and 278 (17%) are only observed once.

Table 1 reports descriptive statistics for the final sample. Average age is close to 39 years, 53.9 percent of observations belong to the treatment group and 46.1 to the control. In terms of outcomes, 39.7 percent of all appointments have been handled (moved or cancelled) and roughly 90 percent of the handling took place over the phone. Close to 44 percent of appointments ended in a completed screening, 38 percent are no-shows, and 18 percent were cancelled. Roughly 3 out 4 cancellations took place because of a recent test, and 1 in 4 for other reasons. The latest screening date is not known for about 85 percent of cancellations for recent tests, and more than 99% of cancellations for whom a test date is not known were handled by phone. We also have information on whether the woman was invited to carry out a HPV (84% of cases) or a PAP (15% of cases) test. In addition, for invitations beyond the first one observed, we also reconstruct the outcome of the previous invitation by type of test, as this determines the spacing between invitations (as discussed in Section 2).

5. Empirical methods

The analysis exploits a difference-in-differences (DiD) design. We identify treatment effects comparing the observed trends in the outcomes over invitations and across the treatment and the control groups. Identification of the effect of the web portal rests upon the assumption that, after the introduction of the portal, the treatment and the control group would have followed the same trend in the outcomes had the web portal not been introduced, and we are able to test this assumption using data for invitations dating back to the period before the introduction of the web portal.

Identification also requires that there are no shocks that hit at the same time of the implementation of the web portal and impacted on the screening behaviour of women in one specific treatment group. The strong control over the institutional setup corroborates the validity of this assumption. The program is carried out within a well-defined geographic area with a homogenous population, and the management of the program falls within a single LHU, that applies the same screening protocols throughout its territory.

Formally, we estimate the following model with Ordinary Least Squares (OLS):

$$Y_{igt} = \beta\, WebOrPhone_g \times Post_t + \phi_t + WebOrPhone_g + X'_{igt}\delta_t + \varepsilon_{igt} \quad (1)$$

In Equation (1), subscripts *i*, *g* and *t* stand for individual, treatment group and invitation, and *Y* is a vector of invitation outcomes. We let *t* be equal to 0 for the current (post-intervention) invitation, and to -1 and -2, for the first- and second-to-last invitation, respectively. $Post_t$ is a dummy variable equal to 1 if *t = 0* and to 0 otherwise, while $WebOrPhone_g$ is a dummy variable equal to 1 for women belonging to the treatment group and to 0 for the others. The main coefficient of interest is β, that is associated with the interaction term between the $WebOrPhone_g$ and the $Post_t$ dummies and identifies the DiD treatment effect. In addition, ϕ_t are invitation round fixed effects, and X_{igt} is a vector of invitation-specific controls that includes age at invitation dummies, a dummy for test type (PAP vs. HPV) and previous invitation test type-by-outcome dummies, that determines the spacing between invitations. In order to capture potential trends in screening behaviour by different demographic groups, we allow the coefficients δ_t of controls in X_{igt} to vary by round. Finally, ε_{igt} is an error term, and we allow for clustering of standard errors by individual.

We test for parallel trends by estimating the following event study specification using OLS:

$$Y_{igt} = \sum_{\tau=-2,0} \beta_t \times 1(t=\tau) \times WebOrPhone_g + \phi_t + WebOrPhone_g + X'_{igt}\delta_t + \varepsilon_{igt} \quad (2)$$

Equation (2) is analogous to Equation (1) but includes the parameter β_{-2}, that identifies the lagged placebo treatment effect given by the comparison between treatment and control groups between the *t=-2* and *t=-1* pre-intervention periods. Under the parallel trends assumption, this coefficient shall be equal to zero for all outcomes.

6. Results.

Table 1 reports the treatment effects on the outcomes of interest as estimated by Equation (1). The outcome variable is listed in the first row of each column, and we report its average value for the control group at *t=0* in the last row.

First, Column (1) shows that the treatment had no significant impact on the probability that an appointment was handled (cancelled or moved). However, Column (2) shows that the (unconditional) probability of handling the appointment by phone decreases starkly, by roughly 18 percentage points or by 50% of the control group mean, suggesting that eligible women who need to move or cancel their slot do take advantage of the possibility to do so online.

Second, results on the outcomes of screening appointments are reported in Columns (3) to (5) of Table 2. Access to the portal reduced screening by 16 percentage points or roughly 30 percent of the control group mean. This is a large effect. A big part of this result – around 10 percentage points or

30 percent of the control group mean – is explained by the increased likelihood of no-shows, which is indeed a negative outcome for the screening program. The remaining part of the result – 6 percentage points or 35 percent of the control group mean – is explained by the increased likelihood of appointment cancellations.

Given their importance from the perspective of the management of the screening program, treatment effects on cancellations deserve further investigation. To begin with, cancellations can happen either because the woman already underwent screening over the last three years or because of other reasons (health conditions, pregnancy, withdrawal from the program). We report treatment effects on the (unconditional) probability of cancelling a slot because the women had already undertaken a test over the last three years or for other reasons in Column (6) and (7) of Table 2, respectively. We see that the higher rate of cancellations detected for the treatment groups is due to a higher likelihood of reporting tests carried out over the previous year, and not to other reasons. Considering that women in the treatment and control groups are comparable in terms of their screening behaviour or health outcomes, this difference is likely due to changes in the probability of *reporting* a recent test, as this is explicitly mentioned as an option for cancellation in the web portal.

In addition, when they communicate recent tests, women are also asked to report the date of the test. Considering that knowledge of this date helps screening managers schedule future appointments with the correct frequency, an interesting question is whether the access to the portal eased women's ability to effectively communicate their last screening date. Columns (8) and (9) of Table 2 illustrate that access to the portal increased the (unconditional) likelihood that women report the date of their last test by 4.4. percentage points. Considering that the control group mean is 1.9 percentage points, this is a very large effect in relative terms.

Finally, Columns (10) and (11) of Table 2 report insignificant treatment effects on the unconditional likelihood of cancellations with or without a reported date handled over the phone, confirming that the positive effect detected on overall cancellations with a reported date of recent screening is due to changes undertaken via the portal.

Importantly, the identification strategy relies on the parallel trends assumption. Figure 1 reports the estimates of the placebo tests and treatment effects estimated from Equation (2). The figure shows that – for all outcomes – the research design delivers parallel trends for the pre-intervention period, as the coefficients for the lagged treatment effect at time $t = -2$ are close to zero and insignificant.

In addition, in Table 3 we show how the estimates in Table 2 change when we:

i) Adjust the significance of the results for the problem of multiple testing using the stepdown method proposed by Romano and Wolf, 2005 (see Panel A). The significance of all treatment effects is unaltered.

ii) Drop all invitation-specific controls and include only invitation round and treatment group fixed effects (see Panel B). The magnitude of the effects becomes smaller, but their signs and significance are unaltered. This result underlines the importance of including covariates and allowing for time-varying effects.

iii) Introduce screening centre fixed effects instead of a single "treatment group" dummy, since assignment to treatment was at the centre level, and allow for clustering of the error term at the same level (in Panel C). Since there are only 4 screening centres, we use the wild bootstrap for inference and use the 6-point bootstrap weight distribution proposed by Webb (2014), instead of the standard Rademacher weights. The magnitude and significance of all effects is confirmed, except for the one on no-shows, that shrinks marginally.

iv) Drop 365 women who changed municipality of residence across invitation rounds or who reside in three municipalities that changed screening centre of affiliation across rounds (in Panel D). Results are again unchanged.

At this stage, it would be interesting to characterise the heterogeneous response to treatment of individual that differ with respect to some personal characteristic related with their propensity to use the web portal. Unfortunately, the only such characteristic that we observe in the data is age. In Table 4 we report the split-sample effects for women aged in 2019 below and above 40, the median age value in the sample. The overall pattern of effects is comparable across the two samples. This is not very surprising, considering that all women in the final sample are of working age, and thus familiar with the use of web services. Still, there are two notable differences. First, the effect on no-shows is predominantly due to younger women. Second, the effect on cancellation is mostly coming from senior women.

7. Discussion: phone aversion, procrastination and the negative effects of the web portal on cancer screening

The most surprising result of the analysis is that giving access to the web portal decreased the probability of attending the screening by roughly 15 percentage points. While part of the decline in attendance can be explained by justified cancellations to avoid overly-frequent screening (which is indeed a positive outcome), around two thirds of the reduction in participation is due to a higher likelihood of unjustified no-shows. In order to rationalize this result, we propose an explanation that is based on several behavioural biases: phone aversion (LaRose, 1999; Rettie, 2007),

procrastination (Akerlof, 1991; Rabin, 1998; Ariely & Wertenbroch, 2002), and limited attention (Della Vigna, 2009).

Our argument is implicitly based on the assumption that the eligible women recognize the benefits of cervical cancer screening and, when receiving the invitation from the LHU, *want* to get screened. The data concerning the pre-intervention period provide empirical support in favour of this assumption as *i)* the take-up of the screening program is rather high in both treatment groups; *ii)* there is a negligible difference in the screening rates between the two groups.

Consider the situation of women who receive invitations to screen on pre-specified dates that are not convenient for them. In the "phone only" condition, women who have either mild phone aversion or no phone aversion at all may prefer to reschedule the appointments via phone. Since these women have the possibility to reschedule their appointments and screen on alternative dates, the pre-specified screening dates are most likely not salient in their memories. Given that the rescheduling of the appointments requires time and effort and there are no binding obligations to proceed to the rescheduling as soon as possible, a fraction of these women may start procrastinating and may delay the rescheduling. Eventually, these procrastinators may either lose the opportunity to change the date of the appointment and miss the screening because of other competing daily obligations, or may forget about the pre-specified appointment overall, given that the screening date is not salient and that they have limited memory.

The situation is somewhat different for the severely phone averse women, who would prefer to undertake the screening on the pre-specified date rather than reschedule the appointments via phone calls. For these women, the pre-specified screening dates are most likely salient in their memories, since these are pretty much the only dates on which they can get screened, given their reluctance to make a phone call and move their appointment.

In the "web or phone" condition, all women – including the severely phone averse ones – have the possibility to reschedule their appointments, as the portal removes the psychological barriers to reschedule the appointments. There is no necessity to make phone calls any longer in order to get screened on alternative dates. Of course, women with no phone aversion may still prefer the call to the platform. Instead, women with mild or severe phone aversion would prefer the portal, since rescheduling through the portal entails no psychological costs as compared to rescheduling through a call. Given that the number of women who can reschedule their appointments increases, so does the number of potential procrastinators (unlike in the "phone only" condition, women with severe phone aversion can also procrastinate, since they can reschedule their appointments via the portal).

Since the number of procrastinators goes up compared to the "phone only" condition, so does the share of no-shows.

This is confirmed by the fact that the estimate of the effect of access to the portal on moved appointments – that can be obtained as the difference between the estimates on handled and on cancelled appointments reported in Table 1 – is negative and equal to -0.043 percentage points. The larger treatment effect on the share of no-shows among younger women is also in line with this hypothesised mechanism, as there is evidence that procrastination is more common at young ages (Gröpel & Steel, 2008; Beutel et al., 2016).

8. Conclusion

Despite the growing adoption of digital technologies in healthcare, there is little systematic evidence on whether these technologies improve the public healthcare systems and result in positive health outcomes for different groups of citizens. Since individuals are the ultimate users of such digital innovations, they may develop complex, heterogeneous, and unpredictable behavioural responses that can even undermine the benefits these technologies can bring with them. As a result, the effects of digital technologies on human behaviour and on the efficacy of the healthcare sector should be rigorously evaluated on a small scale before their widespread introduction to avoid potential negative consequences.

In this paper, we test the impact of a simple web portal that allows eligible women to autonomously modify the cervical cancer screening slot assigned to them by the local health unit managing the program. Interestingly, we document both positive and backfiring effects of this intervention. On a positive note, the web-portal reduces the organizational burden borne by the LHU in managing the screening program since the number of phone calls made by women to the LHU to reschedule their appointments substantially drops. The web-portal also helps to increase the efficacy of the management of the screening program, since women become more likely to report previous screenings and the reasons for cancelling the appointments. These pieces of information are crucial for the correct scheduling of the screening appointments in the future.

On a negative note, we find that giving access to the web portal increases the number of unjustified no-shows, which can have adverse health consequences for the women who missed the appointments. Most likely, the current design of the portal increases the number of women who can procrastinate when rescheduling their appointments, and eventually these women do not screen. To help solving the problem of procrastination, the LHU may decide to send further notifications to the eligible women – on top of the SMS – reminding them to reschedule the appointments. Reminders

represent one of the most popular and effective interventions to steer individuals in a certain direction (Sunstein, 2014) and their positive impact is well-documented in health decisions (Altmann and Traxler, 2014; Antinyan et al., 2021).

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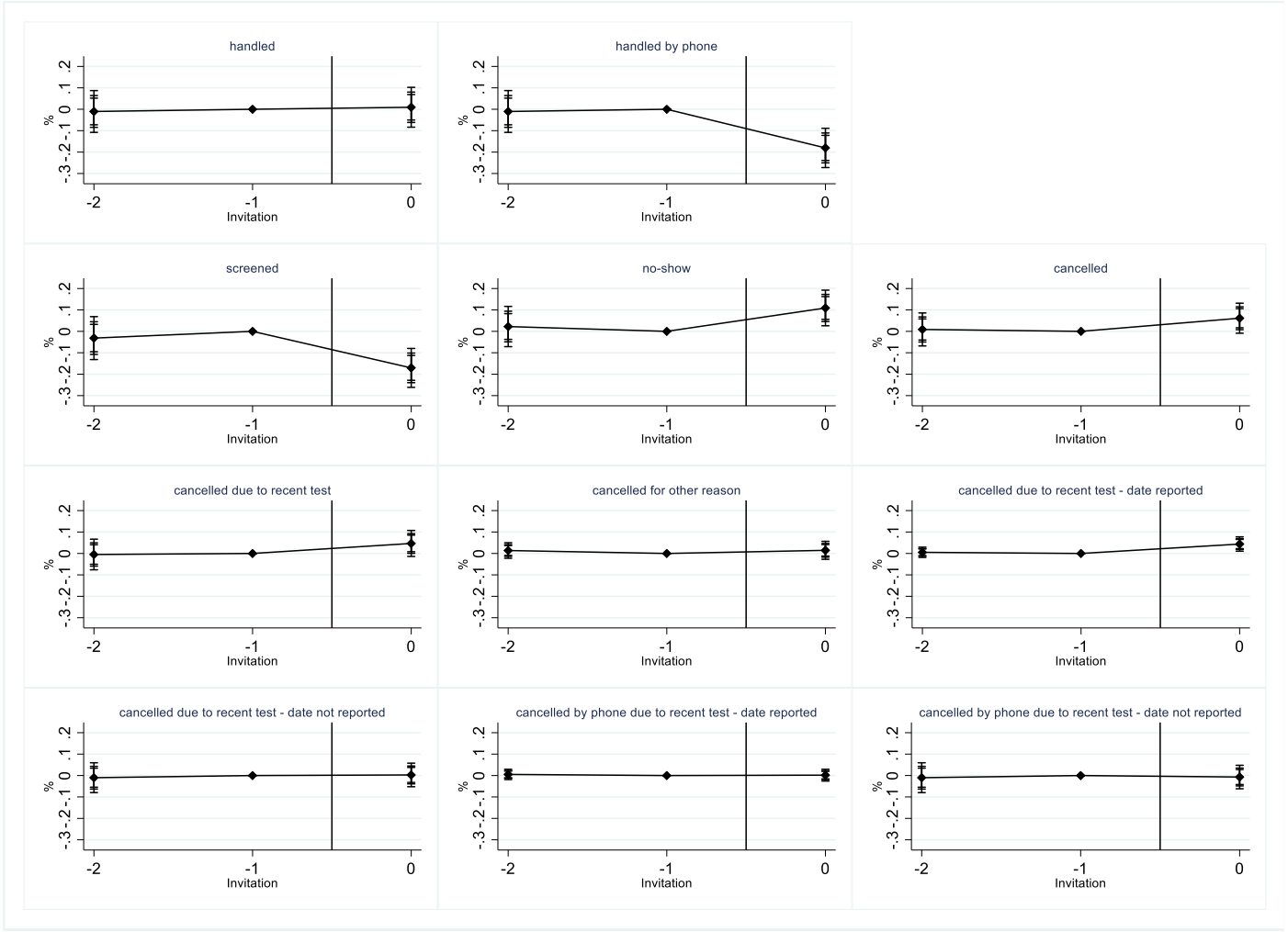
Figures and Tables

Figure 1. The effects of the web portal access on screening outcomes



Notes: The Figure reports the effects of the "web or phone" treatment vs. the "phone only" control group, as estimated from Equation (2), together with their 90, 95 and 99% confidence intervals. The outcome considered in each panel is reported in the heading.

Table 1. Descriptive statistics

	Mean	Std. Dev.
Age	39.121	9.074
Treatment group:		
Phone only	0.461	0.499
Web or phone	0.539	0.499
Invitation outcomes:		
Appointment handled	0.397	0.489
Appointment handled by phone	0.359	0.479
Screened	0.438	0.496
No-show	0.378	0.485
Cancelled	0.184	0.387
Cancelled due to recent test	0.142	0.349
Cancelled for other reason	0.041	0.199
Cancelled due to recent test – date reported	0.022	0.147
Cancelled due to recent test – date not reported	0.120	0.325
Cancelled by phone due to recent test – date reported	0.104	0.118
Cancelled by phone due to recent test – date not reported	0.119	0.323
Pap (vs. HPV) test	0.156	0.363
Previous outcome by test type:		
First test recorded, no previous outcome	0.409	0.492
PAP test, attended	0.024	0.157
PAP test, not attended	0.061	0.240
HPV test, attended	0.222	0.416
HPV test, not attended	0.270	0.444
Pregnant, not attended	0.011	0.105

Notes: the sample only includes invitations for women observed in the age range 25-58. A maximum of four invitations for each women is considered. The sample includes 4,003 invitation-women observation for 1,638 women.

Table 2. The effects of the web portal access on screening outcomes

Dependent Variable:	(1) Handled	(2) Handled by phone	(3) Screened	(4) No-show	(5) Cancelled	(6) Cancelled due to recent test	(7) Cancelled for other reason	(8) Cancelled due to recent test – date known	(9) Cancelled due to recent test – date unknown	(10) Cancelled by phone due to recent test – date known	(11) Cancelled by phone due to recent test – date unknown
Web or phone vs. Phone only	0.014	-0.176***	-0.156***	0.099***	0.057**	0.049**	0.008	0.042***	0.007	-0.001	-0.002
treatment effect	(0.033)	(0.032)	(0.031)	(0.029)	(0.025)	(0.022)	(0.014)	(0.011)	(0.020)	(0.009)	(0.020)
Observations	4,003	4,003	4,003	4,003	4,003	4,003	4,003	4,003	4,003	4,003	4,003
Individuals	1,638	1,638	1,638	1,638	1,638	1,638	1,638	1,638	1,638	1,638	1,638
Mean 'phone only' at *t=0*	0.379	0.379	0.503	0.331	0.166	0.111	0.0548	0.0194	0.0919	0.0194	0.0919

Notes: The Table reports the OLS estimates of parameters β in Equation (1), that identifies the effect on screening outcomes of the "web or phone" treatment vs. the "phone only" control group. Each column is for a different outcome, and outcomes are reported in columns' headings. All regression models include invitation round fixed effects, treatment group fixed effects, age-by-invitation round dummies, test type (PAP vs. HPV)-by-round dummies and previous invitation test type-by-outcome-by-round dummies. Standard errors clustered by individual are reported in parenthesis. ***: p<0.01; **: p<0.01, *: p<0.1.

Table 3. Robustness checks on the effects of the web portal access on screening outcomes

Dependent Variable:	(1) Handled	(2) Handled by phone	(3) Screened	(4) No-show	(5) Cancelled	(6) Cancelled due to recent test	(7) Cancelled for other reason	(8) Cancelled due to recent test – date known	(9) Cancelled due to recent test – date unknown	(10) Cancelled by phone due to recent test – date known	(11) Cancelled by phone due to recent test – date unknown
Panel A. Romano and Wolf, 2005, stepwise resampled p-values robust to multiple hypothesis testing and clustering by individual are reported in brackets.											
Web or phone vs. Phone only	0.014	-0.176***	-0.156***	0.099***	0.057**	0.049**	0.008	0.042***	0.007	-0.001	-0.002
treatment effect	[0.929]	[0.001]	[0.001]	[0.001]	[0.010]	[0.010]	[0.895]	[0.001]	[0.929]	[0.985]	[0.985]
Panel B. Without invitation-specific controls											
Web or phone vs. Phone only	0.025	-0.162***	-0.090***	0.045*	0.045*	0.032	0.012	0.034***	-0.002	-0.004	-0.010
treatment effect	(0.031)	(0.030)	(0.027)	(0.026)	(0.024)	(0.020)	(0.014)	(0.011)	(0.019)	(0.008)	(0.019)
Panel C. With screening centre fixed effects instead of a treatment group dummy. Wild bootstrap p-values adjusting for clustering by screening centre are reported in brackets.											
Web or phone vs. Phone only	0.012	-0.178***	-0.158*	0.102	0.057*	0.049**	0.008	0.041*	0.008	-0.001	-0.001
treatment effect	[0.678]	[0.028]	[0.058]	[0.183]	[0.079]	[0.044]	[0.587]	[0.090]	[0.471]	[0.869]	[0.897]
Panel D. Dropping women who change residence across invitation rounds or who reside in three municipalities that screening centre of affiliation across rounds											
Web or phone vs. Phone only	0.013	-0.181***	-0.161***	0.083***	0.077***	0.061**	0.016	0.045***	0.016	0.000	0.005
treatment effect	(0.037)	(0.036)	(0.034)	(0.031)	(0.029)	(0.026)	(0.017)	(0.013)	(0.023)	(0.010)	(0.023)
Mean 'phone only' at *t=0*	0.379	0.379	0.503	0.331	0.166	0.111	0.0548	0.0194	0.0919	0.0194	0.0919

Notes: The Table reports the OLS estimates of parameters β in Equation (1), that identifies the effect on screening outcomes of the "web or phone" treatment vs. the "phone only" control group. Each column is for a different outcome, and outcomes are reported in columns' headings. Observations: 4,003 (3,096 in Panel D). Individuals: 1,638 (1,273 in Panel D). Screening centres: 4. In Panel A, all regression models include invitation round fixed effects, treatment group fixed effects, age-by-invitation round dummies, test type (PAP vs. HPV)-by-round dummies and previous invitation test type-by-outcome-by-round dummies. In Panel B we only include invitation round fixed effects, treatment group fixed effects. In Panel C we include screening centre fixed effects instead of a treatment group dummy. Standard errors are clustered by individual in Panels A and B and by screening centre in Panel C. We used 1000 replications for the Romano and Wolf, 2005, stepwise resampling method in Panel A as well as for the wild bootstrap in Panel C. In Panel C the number of clusters is below 11. As a result, we use the 6-point bootstrap weight distribution proposed by Webb, 2014, instead of the standard Rademacher weights. ***: p<0.01; **: p<0.01, *: p<0.1.

Table 4. The effects of the web portal access on screening outcomes by age in 2019 above or below median (40 years)

Dependent Variable:	(1) Handled	(2) Handled by phone	(3) Screened	(4) No-show	(5) Cancelled	(6) Cancelled due to recent test	(7) Cancelled for other reason	(8) Cancelled due to recent test – date known	(9) Cancelled due to recent test – date unknown	(10) Cancelled by phone due to recent test – date known	(11) Cancelled by phone due to recent test – date unknown
Panel A. Junior women, age<40.											
Web or phone vs. Phone only	-0.021	-0.261***	-0.203***	0.160***	0.043	0.039	0.004	0.049***	-0.010	-0.001	-0.021
treatment effect	(0.049)	(0.047)	(0.046)	(0.044)	(0.036)	(0.030)	(0.025)	(0.017)	(0.026)	(0.013)	(0.026)
Observations	1,708	1,708	1,708	1,708	1,708	1,708	1,708	1,708	1,708	1,708	1,708
Individuals	776	776	776	776	776	776	776	776	776	776	776
Mean 'phone only' at t=-1	0.398	0.398	0.478	0.334	0.188	0.102	0.0860	0.0223	0.0796	0.0223	0.0796
Panel B. Senior women, age≥40.											
Web or phone vs. Phone only	0.035	-0.106**	-0.122***	0.050	0.072**	0.054*	0.018	0.035**	0.019	0.001	0.011
treatment effect	(0.044)	(0.043)	(0.041)	(0.037)	(0.034)	(0.031)	(0.016)	(0.015)	(0.029)	(0.012)	(0.028)
Observations	2,295	2,295	2,295	2,295	2,295	2,295	2,295	2,295	2,295	2,295	2,295
Individuals	862	862	862	862	862	862	862	862	862	862	862
Mean 'phone only' at t=-1	0.359	0.359	0.529	0.327	0.144	0.121	0.0229	0.0163	0.105	0.0163	0.105

Notes: see Table 3.

Appendix 1. Additional results

Table A1. The assignment of screening centres to treatment groups.

Screening centre	Affiliated municipalities	Invitations from 01/11/2018 to 31/01/2019		Invitations from 01/11/2017 to 31/01/2018	
		Invitations	Screening take-up rate	Invitations	Screening take-up rate
1. "Phone only" group					
Screening centre 1	5	1174	55.9	1289	63.8
Screening centre 2	6	584	65.1	728	52.7
Total		1758	58.96%	2017	59.79%
2. "Web or phone" group					
Screening centre 3	7	1103	66.5	1143	64.2
Screening centre 4	2	522	54.4	569	60.3
Total		1625	62.61%	1712	62.90%

Appendix 2. The invitation letter and the leaflet presenting the web portal.

[We report both the invitation letter and the leaflet introducing the web portal sent to women in the "web or phone" group. All the identifiable information has been removed and replaced by general indications in brackets. The only difference between the invitation letter in "web or phone" and "phone only" was that, in the latter, no reference to the web portal was included. Moreover, the letter sent to women in the "phone only" group did not include the leaflet presenting the web portal. The invitation letter was originally written in Italian.]

A.2.1. The invitation letter

[LOGO OF THE LHA]

[DENOMINATION OF THE LHU]
Department of Prevention
Cytological Screening Program

[PLACE],

Dear Madam,
We invite you to participate in the national screening program for the **prevention of the cervical cancer**, organized by [DENOMINATION OF THE LHU], in adherence with the guidelines of the Region [REGION OF THE LHU].
The exam will be conducted by specialized healthcare personnel and will consist of a single sample collection for both the **HPV test** and the **PAP smear.** The latter will be considered only in case of a positive result from the HPV test. The sample collection for these tests is simple, painless and takes only few minutes. We scheduled the following appointment for you:

[DATE OF THE APPOINTMENT] [TIME OF THE APPOINTMENT]
[ADDRESS OF THE APPOINTMENT]

The exam is **free of charge** and does not require any prescription from your GP. On your request, we will provide a certificate of attendance to justify your absence from work. We will send the outcome of the exam directly at home by mail.
If you have attended a Pap test or a HPV test in the last three years outside of the screening program, it is not necessary to undertake the proposed exam and we kindly ask you to cancel the appointment.
To change the appointment, to cancel it or for any other information you can **access the "[NAME OF THE SCREENING WEB PORTAL]"** of the Region [REGION OF THE LHU] ([WEBSITE OF THE SCREENING WEB PORTAL]) by following the indications that you find on the back of this letter and by using your Tax Code and the following password, **or by contacting the screening secretary** at the phone number [PHONE NUMBER OF THE LHU] from 10.30 to 13.30, from Monday to Friday.

Tax Code: XYZBCA65C30F123P
Password: AbC_$1234

Remember:
- Bring this letter with you, together with your health insurance card and your ID card;
- Only undertake the examination at least three days after the end of the menstrual cycle and if you do not have blood losses;
- Do not have sexual intercourses, even protected, and avoid undertaking vaginal ultrasounds or gynecological examinations in the two days before the test;
- Do not use vaginal suppositories, creams or douches in the three days before the test.

We trust in your participation, and we send sincere greetings.

The Director of the Department of Prevention
Dr. XYZ

A.2.2. The leaflet presenting the web portal

[LOGO OF THE REGION]	ONCOLOGICAL SCREENING PROGRAM FOR PREVENTION OF THE CERVICAL CANCER	[LOGO OF THE LHA]

MANAGING THE APPOINTMENT ONLINE TO FREE UP YOUR OWN TIME

Dear Madam,

through the web portal dedicated to the oncological screening program of the Region [REGION OF THE LHU] "[NAME OF THE SCREENING WEB PORTAL]", it is possible to manage your appointment to the screening test (the PAP smear or the HPV test) autonomously.

To access to the web portal, visit the following website: [WEBSITE OF THE SCREENING WEB PORTAL] (even from your smartphone) and enter your Tax Code and the personal password included in the invitation letter.

TWO MINUTES FOR YOURSELF

By using the **[NAME OF THE SCREENING WEB PORTAL]** you can easily confirm, modify, or cancel the appointment reserved for you. Your appointment will be managed:

- **quickly**, saving the precious time of the telephone waiting
- **freely**, being the web portal accessible at any time
- **flexibly**, giving you the possibility, if needed, to modify the appointment many times, by visualizing the slot availability on the online calendar

If you will not come to the appointment because you have already undertaken an examination privately, it is important to enter the date of the test. This will allow us **to contact you again in future** with optimal timing to offer a new opportunity to participate in the screening program.

If you **do not want to undertake the proposed screening test**, for instance because you already undertake regular tests with your doctor, it will only take few seconds **to cancel your appointment**.

Your collaboration is important!