Reducing Abandonment and Improving Attitudes in Emergency Departments: Integrating Delay Announcements into Operational Transparency to Signal Service Quality

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Problem definition: Emergency Departments (EDs) impose a complicated service process on patients and accompanying family members (from now: people). ED patients typically encounter long waits, various procedures, and multiple staff members. People lack knowledge about the various elements their ED journey will comprise. We suggest that providing people *Personalized Information about Operations and Time* (PIOT), i.e., information about the procedures and anticipated wait times, will improve their sense of understanding and sense of progress during the ED journey, resulting in improved satisfaction. PIOT is also expected to directly reduce patients' likelihood of abandonment. We combine research on operational transparency (shown to improve attitudes) and delay announcements (shown to reduce abandonment). We build on signal theory to argue that PIOT signals service quality, thereby inducing positive outcomes. We show that perceptions of understanding and progress play an essential role in the complex context of medical service.

Methodology/results: We ran a field study in a medium-sized hospital to test how PIOT affects people during their ED stay. PIOT is provided in "MyED", a system based on Electronical Medical Records (EMRs) that reveals elements of the ED journey previously unknown to patients and family members. We tracked people's use of the system, and varied two dimensions of PIOT (i.e., operational and time information) over four cycles, or two weeks each. We show that providing operational information is enough to improve people's sense of understanding, but to improve people's sense of progress and satisfaction time information also needs to be provided. Interestingly, PIOT reduced patients' likelihood to abandon the ED by 26.67% (from 3% to 2.2%), but only if time information was not provided.

Managerial implications: Providing PIOT offers a novel approach to improving healthcare service, addressing typically overlooked psychological needs of people in EDs for information and understanding.

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1. Introduction

1.1. Context of ED Complexity

Patients and family members (from now: people) arriving at Emergency Departments (EDs) are often stressed and confused (Blackburn et al. 2019). The unknown medical situation that brings people to an ED makes them anxious and vulnerable. People also arrive with expectations for quick medical action, yet are typically met with a need to wait for tests, diagnoses, and treatments (Blackburn et al. 2019). ED stays thus create helplessness, partly because of the medical uncertainty and partly because of the delays that are inevitable in the ED environment. People usually spend three or more hours in the ED (Horwitz et al. 2010), with recurring waits for physicians, treatments, tests, or decisions (Blackburn et al. 2019). Such long waits hamper patience and can drive people to go home rather than finish treatment (Batt and Terwiesch 2015), a type of abandonment that may endanger patient safety and increase mortality (Hoot and Aronsky 2008).

EDs (like many other medical systems) typically use electronic medical records (EMRs) to track the process and patient-care information. In parallel, research shows that offering information can improve people's experience in the ED (Efrat-Treister et al. 2020). We therefore propose that developing a system based on EMRs that provides people with personalized information regarding their ED journey can significantly improve ED service. Traditionally, only the staff have access to EMRs, so people must depend on the staff for information about all the assessments, tests and treatments, and ED resources (e.g., specialists, nurses, labs, imaging) their care will require (Kannampallil et al. 2011). We visualize typical ED journeys with a process chart, as depicted in Figure 1. Each patient in the process is represented by a colored dot, and has a unique route that involves doctor admission and discharge (or queue for hospitalization) (represented by ovals) and various other system resources (represented by squares).

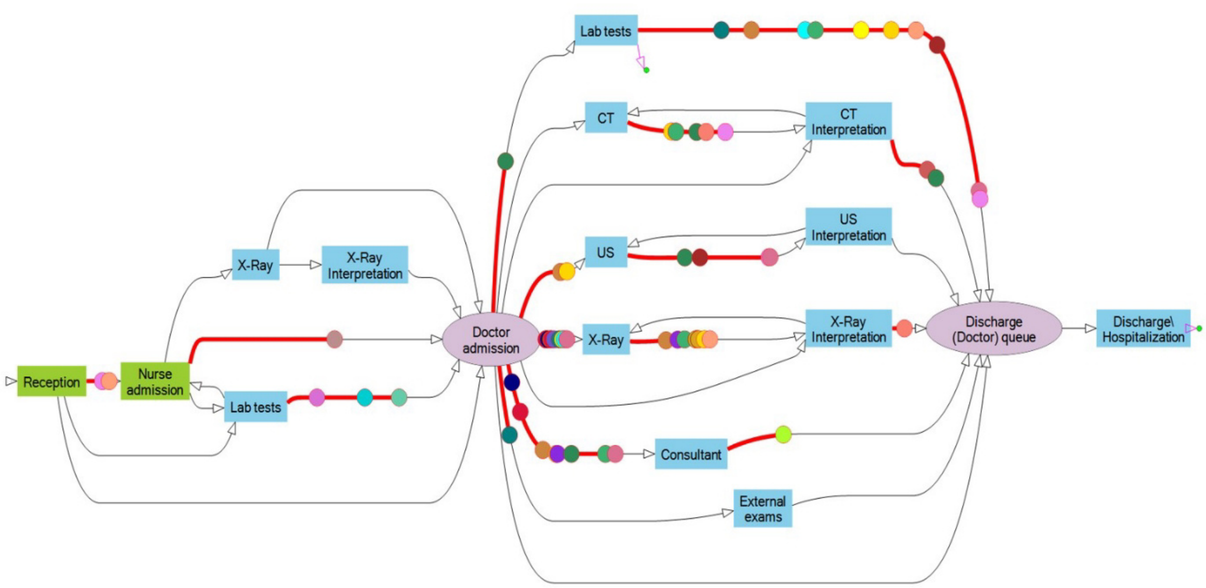

Figure 1 **Process network: A snapshot of patient flow through an ED. Animation of the data is available at:** https://www.youtube.com/watch?v=HP_au996Ffw.

Yet, the full complexity of ED service is not evident in this figure. It is not enough to study individual patient resources, the larger network has to be taken into account (Kc et al. 2020). Further complications are created by variations in arrival rates, unknown and rapid changes in patient needs, and urgency of some arriving patients. These complications create operational and managerial challenges, and make patient cooperation essential for efficient ED operation (Kannampallil et al. 2011). As we develop below, we propose that more sharing of information with people in the ED can facilitate cooperation.

1.2. Co-production in Medical Services

The concept of service co-production acknowledges the unique notion that services are jointly produced by service providers and customers (Brandsen and Pestoff 2006). Customers take an active part in designing, implementing and/or acquiring services (Palumbo 2016), and service success relies on customer contributions (Ostrom et al. 2002). Co-production is especially relevant in knowledge-intensive professional services (Ostrom et al. 2002), healthcare being a premium case (Palumbo 2016). For example, patients must describe symptoms, take medication, or go to a clinic for tests. Yet, this interdependence is not paralleled by symmetric information access between staff and patients. The information is available to the staff in EMRs, with no clear protocol for sharing it with patients. The severe pressures and competing demands of medical work can stall even brief communication of information by the staff (Blackburn et al. 2019). Thus, people are often only partially informed about their ED journey. People do, however, crave the attention of medical staff, and specifically information about the prospective elements of their ED journey (Finefrock et al. 2018). We thus propose that providing information to people about their ED journey can improve the ED experience.

1.3. Patient-centered Care—Tailoring Information to Patient Needs

ED care must be patient-centered, focusing on the specific needs of each patient (Finefrock et al. 2018, Flynn et al. 2021). Patient-centered care is essential for effective health outcomes and for people's satisfaction (Flynn et al. 2021, Becker and Douglass 2008). We highlight a missing step in current patient-centered care: offering people information regarding the set of procedures that make up their *patient journey* (Trebble et al. 2010). The patient journey is a medical version of the marketing term *customer journey*, which refers to activities constituting customer experiences (Lemon and Verhoef 2016). Research on ED journeys is limited, and what we have found does not address individual needs. For example, Efrat-Treister et al. (2019) created a poster to educate people about the complexities of ED systems. But individual variations in ED journeys were not captured by these posters; for example, the one described by Efrat-Treister et al. (2019) mentioned ED stays would last 5 hours on average, while actual patient journeys can take from less than one hour to more than 12 hours. Hence, effective patient-centered care would offer more personalized information. Research suggests that patient-centered care must offer people information about what *they* are waiting for and about how long *they* are likely to have to wait (Blackburn et al. 2019). We build on this research in testing a system which provides people information about procedures and anticipated wait times.

1.4. Study Rationale

Our study examines (1) what type of information helps people in EDs: process-related (operational-only) information, or process and time-related information; and (2) what impact the provision of such information has on people's attitudes (sense of understanding, sense of progress, satisfaction) and patients' behavior (abandonment). We examine the effects of provided information using a system called MyED, described in detail elsewhere (cf. Westphal et al. 2020). In brief, the system extracts information from the EMRs and uses refined algorithms to identify the ED journey for each patient. People learn about and access MyED through a text message sent to their personal cellphone upon ED registration. The information MyED shows is illustrated in Figure 2, and includes information about completed and next ("Now" and "Later") stages, wait times for the next stage, and estimated total time in the ED. It is updated every five minutes. MyED is user-friendly, ensures security and privacy, and does not provide any medical assessments or results.

Our study draws from a theoretical integration of research on *operational transparency* (cf. Buell et al. 2017, 2020) and on *delay announcements* (cf. Ibrahim et al. 2017). Historically, these are two separate bodies of work. Yet, both show that people appreciate the extra step taken by an organization to unveil specific elements of the service process. Delay announcements inform people how long they must wait to receive service, and are known to increase patience and thereby reduce abandonment (Ibrahim et al. 2017). Operational transparency informs people about elements in the service process (e.g., information search, food preparation), and is known to improve people's attitudes (Buell et al. 2017, 2020). Our study adds the element of *personalized information*, meaning information tailored to meet individual needs (Drakopoulos et al. 2021). Research on delay announcements typically regards information that is identical for all customers with little or no attention to individual differences. Limited research shows that personalized information can improve reactions to stressful situations (Kondylakis et al. 2015, 2013). Integrating these disparate bodies of literature, we argue that providing people *Personalized Information about Operations and Time* (PIOT) can improve outcomes for people in EDs. We propose signaling theory (cf. Spence 2002, Connelly et al. 2011) as the theoretical framework to connect the multiple bodies of literature on which we build. Using MyED, we construe PIOT—the combination of operational transparency, delay announcements, and personalized information—as a signal of service quality. Services are

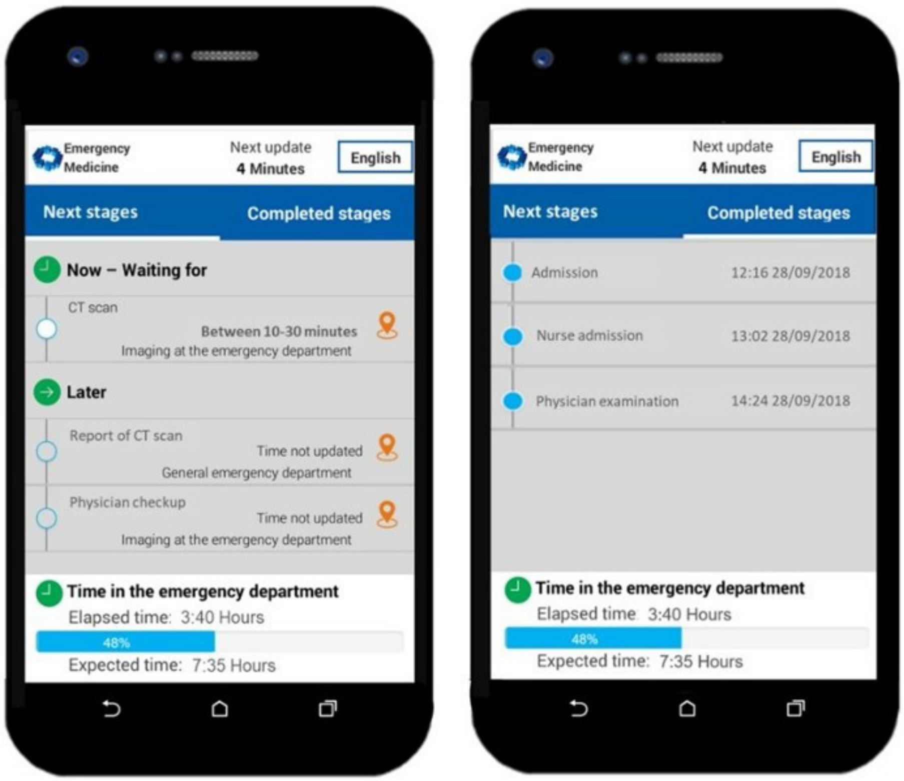

Figure 2 **Screenshots of MyED user interface (available to an actual patient on September 28, 2018, 15:56).**

intangible, so organizations are forced to develop signals to induce positive impressions of quality (Boulding and Kirmani 1993). The more intangible a service, the more critical such signaling becomes. In ED service, PIOT signals effort and care for each individual person. We propose that this signal helps people experience the ED visit more positively because it helps them understand their personal ED journey and feel the progress they make throughout it.

We tested our predictions in a field study (Period I: 07/2019 to 02/2020; Period II: 03 to 07/2021) in which we assessed attitudes and abandonment of people in the ED of a medium-sized hospital. (We had to stop data collection during the COVID-19 pandemic, hence the two time periods.) The target sample varied according to the outcomes we looked at: people's attitudes were recorded in surveys ($N = 677$), and patients' abandonment was recorded in the EMRs ($N = 18,226$). Depending on the week, people using MyED were exposed to different dimensions of PIOT (i.e., operational-only information, or operational and time information). People who did not receive any text message to access MyED (for various reasons) constituted the control condition. We expect PIOT to promote people's sense of understanding and of progress throughout their ED journey. The increased sense of understanding and progress should further yield improved attitudes of satisfaction. We also expect PIOT to directly influence a problematic yet common behavior in EDs: patients' abandonment.

1.5. Main Contributions

First, we contribute to literature on operational transparency in services by showing its merits in complex healthcare service: revealing elements of an ED journey to people improves their attitudes *during* their ED stay. Second, we extend the literature on delay announcements, which so far has focused on reducing customer abandonment *before* service delivery. We show that delay announcements can assist people *during* delivery of health service—in completing it. Hence, they have great potential to prevent (further) health deterioration. Third, we show the effectiveness of *a combination* of delay announcements and operational transparency, paired with personalized information, in improving outcomes. Further, we position signaling theory as explaining the utility of *Personalized Information about Operations and Time* as a signal of service quality by manifesting efforts of a service provider to care for individual people and to promote understanding of the complex service process. We extend signaling theory by showing that signaling can benefit not only the organization, but also the customers. Next, we provide experimental evidence of improvements in satisfaction due to an increased sense of understanding and progress during personal ED journeys. This shows the benefit of developing PIOT communication systems for ED services. Lastly, we show effects of delay announcements and operational transparency in multistage, complex service that lasts several hours, complementing previous research which focused on services that last several minutes.

2. Theory Development

2.1. Intangibility of Services, Waiting, and the Role of Signaling

Services are intangible, so organizations must develop signals that imbue people with positive impressions of quality (Boulding and Kirmani 1993). The more intangible a service, the more critical such signaling becomes. For example, in phone or chat services, people cannot see what an employee is doing; therefore, cues about the quality of the service are critical. Heterogeneity in customer and employee abilities further complicates evaluations of service quality, as it hinders consistency in meeting expectations. In addition, production and consumption of services are inseparable, meaning that evaluations of service quality must regard both processes of service delivery and obtained outcomes. The former is known as the *service experience* (Helkkula 2011) and the latter as *service evaluation* (Brady et al. 2005).

Evaluations of service quality often rely on the attention of the employee (Turel and Connelly 2013) or on wait time (Kremer and Debo 2016). Appraisal theories suggest, for example, that people may infer from a long employee response time that the employee is lazy and thus develop a negative attitude (Turel and Connelly 2013). Transparency is one way to handle this predicament, influencing service evaluations by swaying people's attention away from the waiting. Organizational outcomes, such as queue abandonment, are also improved (reduced) by such signaling and swaying of attention (Munichor and Rafaeli 2007).

In ED service, however, such signaling is extremely difficult. People routinely spend about a third of their visit waiting (Horwitz et al. 2010), and people's attention is occupied by anxiety about the medical condition. There is nothing they can do to expedite the medical care (Becker and Douglass 2008), which makes wait times key indicators of service quality (Kremer and Debo 2016, Becker and Douglass 2008). Providing "simple" delay announcements cannot be a solution in EDs, because the dynamics of ED service are unique to each patient and frequently change during the wait because of unexpected medical turns. Hence, people are likely to seek other cues in the environment to decipher service quality.

In services with less complexity, organizations have reduced uncertainty by providing real-time information that tracks elements of the service delivery (e.g., see Domino's Pizza Tracker, FedEx Tracking, or American Airlines' Baggage Tracker). The underlying idea is that information reduces uncertainty and increases trust by demystifying the service process (Eisingerich and Bell 2008). Demystification occurs by providing information that is clear, easily accessible, understandable, relevant, and useful. Previous studies of information about elements of ED service typically regarded general information. ED visits, however, concern service to a specific person, making general information (about an average person) inaccurate and potentially frustrating for a typical patient (Efrat-Treister et al. 2020). Based on signaling theory (cf. Spence 2002, Connelly et al. 2011), we propose that PIOT can be an effective tool for signaling service quality to people in the ED. PIOT is a signal that can help improve people's experience in spite of the complexity, crowdedness, and long waits that ED service entails.

2.2. Signaling Theory—An Introduction

The true quality of products and services is not obvious to customers, so various cues are used to signal quality (Boulding and Kirmani 1993). A signal may induce changes in people's behavior (e.g., purchasing), or a change in attitude (e.g., satisfaction), depending on its message and interpretation (Connelly et al. 2011). Signaling researchers study customer-organization interactions as instances of information asymmetry between parties (Spence 2002, Connelly et al. 2011), and focused on communicating positive organizational attributes as a strategic tool that can benefit the organization (sender of the signal). Researchers called for examining the role of receivers (here: customers) in the signaling process (Connelly et al. 2011).

Hospital EDs are institutions that must communicate the quality of their medical service to people. However, hospitals inhabit information asymmetry, since traditionally, only medical staff (who can access EMRs) are fully informed about people's ED journeys. This information asymmetry sends a bad signal to people, making them feel helpless. Towards reducing these feelings of helplessness, we propose that PIOT can send a (positive) counter signal—of ED-service quality. By revealing personalized operational and time information, a hospital ED signals care for how people feel, concern for their needs, and a concerted effort to help them understand their ED journey. We thus broadly propose that PIOT will improve people's attitudes and (desired) behavior with the ED service.

2.3. Information about Service Processes as a Signal

A next point in our theory is that the information provided signals service quality. We distinguish three service-delivery practices of sharing information: (1) operational transparency; (2) delay announcements; and (3) personalized information.

2.3.1. Operational Transparency as Signaling. Operational transparency (cf. Buell et al. 2017, 2020) makes salient the entire set of elements composing a service process. For example, customers who watch food being prepared report more organizational effort and an increase of 22% in quality perceptions (Buell et al. 2017). Similar positive effects occur when websites signal effort by showing customers waiting for flight information which airlines are being searched (Buell and Norton 2011). Perceptions of increased effort further boost satisfaction and perceptions of the value of the service. Transparency can also change customer behavior. For example, showing citizens that their service requests are being handled increased the number of submitted citizen requests by 60% (Buell et al. 2020). Increased perceptions of effort, appreciation, and trust in the government explained people's higher engagement with the government over time. In short, operational transparency occurs when effort is exerted to show people what is happening behind the scenes. We theorize this as signaling service quality, which induces positive reactions such as improved satisfaction and value perceptions as well as improved overall organization performance.

In the more complex context of hospital EDs that we study, transparency about how the service is done is in part naturally embedded in the process when staff meet patients face-to-face for examinations and diagnoses. However, other parts of the service are commonly hidden; notably, why people have to wait. Waiting may be required because other patients are being served, because a lab is processing tests, or because results of tests or X-rays need to be interpreted, for example. Privacy and medical concerns limit the elements of ED service that can be made transparent. Unlike in restaurants, the full medical process cannot be shown, posing a challenge to signaling service quality. We propose, however, that sharing with people the procedures that their ED journey will contain and the anticipated wait times for each procedure—aspects not constrained by privacy or medical concerns—are effective signals of the effort that ED service entails. We propose that PIOT can act as a signal for service quality: that the hospital is exerting an effort to make people understand what is happening behind the scenes. We propose that such signaling improves people's understanding and satisfaction in the ED:

Hypothesis 1 (H1) *PIOT improves people's sense of understanding of their ED journey.*

Hypothesis 2 (H2) *PIOT improves people's satisfaction with the ED service.*

We further propose that people's sense of understanding is a main cause of their overall improved satisfaction with the ED service. Hence, we posit sense of understanding as a mediator between the information signal and satisfaction with the ED service:

Hypothesis 3 (H3) *PIOT improves people's satisfaction with the ED service through their improved sense of understanding.*

All propositions are summarized in Figure 3.

2.3.2. Delay Announcements and Signaling. A second service-delivery practice that we propose signals service quality is delay announcements (Allon et al. 2011). Various empirical studies tested the impact of delay announcements on customer attitudes and abandonment (cf., Ibrahim 2018). Most of this research examined vocal announcements in call centers, confirming their influence on customer choices and system performance. Delay announcements are particularly common in non-visible queues (Huang et al. 2017), precisely where signaling is likely to be important and helpful. The underlying assumption is that delay announcements can increase people's patience and thus reduce abandonment (Yu et al. 2017). Delay announcements can include very vague to very precise information (Allon et al. 2011) and can be presented to people at different points of time during their wait (Huang et al. 2017). For example, in a simulated telephone wait Munichor and Rafaeli (2007) showed that updating people about their place in queue (compared to two no-information conditions: music and apology) improved their sense of progress and satisfaction. Similarly, Weiss et al. (2008) provided callers information about their position in queue, informing them that the queue is either long or short, and providing them with either many or few updates. Results indicate that many updates make people more satisfied by improving their sense of progress, and that when a queue is announced as short, there is less abandonment through an improved sense of proximity.

In the ED context, showing people how much time they must wait seems to be especially relevant, since waits during ED visits can take several hours. Yet, people are anxious to make progress toward solving their medical problem. At the same time, it is challenging to announce accurate delays in EDs because of the substantial complexity of the service and the dynamic nature and frequent changes inherent to medical service processes (Carmeli et al. 2022). For example, there may be unexpected complications or necessary tests for a patient, or new arrivals to the ED in a critical condition may impose unanticipated delays. We implement three solutions to this problem.

First, we present wait times as a range (e.g., "between 30 and 45 min") rather than a fixed amount of time (e.g., "40 minutes"). As Allon et al. (2011) noted, people react more positively to vague (rather than exact) delay announcements. Presenting a range rather than precise times is likely to make the delay information more vague. Moreover, Westphal et al. (2020) reported that people find range announcements more trustworthy than exact announcements. Second, in addition to wait times for each station, we also provide an estimate of the overall time a person should expect to stay in the ED (i.e., total length of stay [LOS]). Third, we introduce continual updates to the wait time information (every 5 minutes). This means that people can see adjustments in their wait times as they progress through their ED journey, which we expect will help create a sense of dynamic progress for the people involved. We propose that this information acts as a signal of service quality: that the organization makes an effort to help people see the progress they make. Thus, we predict that providing people PIOT improves their sense of progress during the ED journey, see also Figure 3:

Hypothesis 4 (H4) *PIOT improves people's sense of progress during their ED journey.*

We further propose that people's increased sense of progress is an additional antecedent to overall improved satisfaction with the ED service. Hence, we posit sense of progress as a second mediator between the information signal and satisfaction with the ED service, besides sense of understanding:

Hypothesis 5 (H5) *PIOT improves people's satisfaction with the ED service through their improved sense of progress—regardless of their sense of understanding.*

We also expect PIOT to reduce patients' abandonment of the ED. We base this expectation on extensive research on customer abandonment in call centers. This body of research found call center customers to be the least patient when they do not receive any delay announcements (Jouini et al. 2011). Yu et al. (2020) find that both the magnitude of the initial delay announcement and the update frequency affect customer abandonment. Frequently informing telephone customers about their progress in a queue yields positive affective reactions and lower abandonment rates (Munichor and Rafaeli 2007, Weiss et al. 2008). There is some complication to these effects by the issue of whether the information provided by delay announcements is accurate or not. For example, when the wait time exceeds the announced delay, people are more likely to abandon (Jouini et al. 2011). Thus, for PIOT to create the effects we predict, we strive to provide accurate time information.

Previous work on delay announcements is mostly on services that are less complex (compared to EDs), and non-physical, such as call centers. Yet, delay announcements are clearly important in the ED context, where people spend hours (physically) waiting for treatment. Moreover, traditional research on delay announcements presumes all customers have a more or less identical service journey. The unique service needs of each person have been implicitly assumed irrelevant in this research. People in an ED, however, have very different needs and medical journeys from each other. Hence, the information that will help them is personalized information about their specific ED journey rather than generic information based only on the queue size. Our key contribution is in examining delay announcements that are tailored to each person based on individual needs and situations. The provided PIOT recognizes variations between various ED clients and takes individual medical needs into consideration. Such personalized information should yield high levels of information accuracy and serve as a signal of service quality sent by the hospital to the people waiting. We expect this signal to reduce patients' abandonment from the ED (see Figure 3):

Hypothesis 6 (H6) *PIOT reduces patients' likelihood to abandon the ED.*

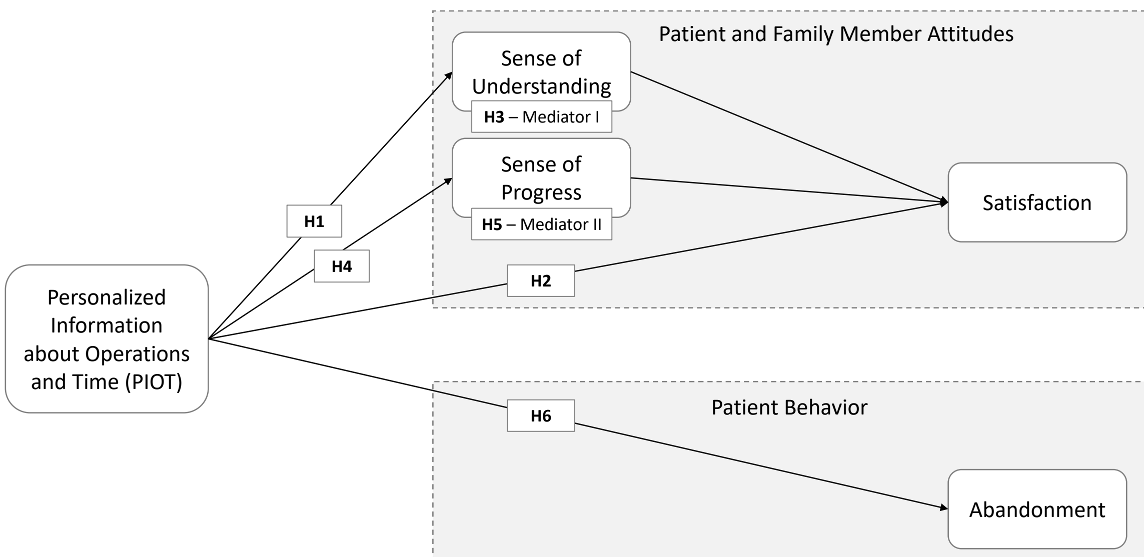

Figure 3 **Research Model—Effect of PIOT on people's attitudes and patient behavior**

2.3.3. Personalized Information about Operations and Time, and Signaling. Previous research examined mostly non-personalized information. However, the time people must wait for service (in an ED or elsewhere) is likely to vary, depending on their unique needs or attributes, such as specific service needed, history with the organization (e.g., frequent flyer or members of an organizational club), or financial standing (e.g., VIP or business-class customers). To the best of our knowledge, there is little empirical research on the effect of operational transparency tailored to specific people. Among them are Buell et al. (2020)—who examined how citizens react to showing that *their* service requests are being handled—and Bray (2020)—who investigated how customers respond to real-time tracking of *their* packages.

Customers in Buell et al. (2017) could watch the preparation of sandwiches but not necessarily the sandwich they had ordered. Similarly, in Buell and Norton (2011), all people who searched for flights received identical information, independent of their personal needs. Examples of PIOT include real-time trackers (e.g., Domino's Pizza Tracker and FedEx Tracking) that provide people with detailed information about the process through which their desired product is moving toward them (e.g., pizza, package, or luggage), including the location for each step and, in some cases, anticipated (arrival) times. Hence, the information provided varies according to the specific customer's needs and order. In contrast, many versions of delay announcements, such as "all service agents are currently busy" are not personalized to the specific person attributes. Indeed, there might be some personalizing in the offered information (e.g., a delay of 4 min vs. 5 min according to the queue length that the specific person encounters), but this attends only to time-related, organizational (here: queue) attributes, not to any unique individual needs, behaviors, or attributes. Hence, this is not fully personalized information. Previous research on ED information offered only general information about average delays in ED. We, on the other hand, offer personalized information, which relies on the individual EMR.

Personalized information has been shown to be effective in inducing behavioral change (Klöckner and Ofstad 2017). Segmenting customer groups according to specific attributes can help adapt marketing strategies to distinct customer groups, which is known to improve loyalty and increase performance (Terho et al. 2015). Pricing can also be personalized (Drakopoulos et al. 2021). Latimer et al. (2008) found that part of the positive effect of tailored information is caused by the reduction of the amount of information that people must process.

Provision of online health information can also be personalized. As described by Alfano et al. (2019), new systems collect information on individual attributes and develop a lexicon of potential responses that match people's health information needs. AI systems enable predictions of people's unique health information needs and provide them with relevant information. Similarly, information that takes into account demographics and acuity allows people to obtain better healthcare (Wang et al. 2019). And, recommended treatment plans through personalized medicine offer health planning, treatment strategies, and drugs customized to individual patients (Chen et al. 2021). However, providing personalized information can only lead to positive outcomes if people understand it. Hence, there is a call for experimental research to determine the correct balance between information accuracy and simplicity (Wang et al. 2019). We respond to this call and propose that

PIOT signals service quality: that the organization offers people a direct and personal connection. Transferred to the ED context, the hospital aims to efficiently and effectively address people's needs throughout the ED journey. Taking everything together, we propose that PIOT will increase people's sense of understanding and sense of progress during their ED journey and thereby lead to improved satisfaction with the ED service. We also expect PIOT to directly reduce patients' abandonment from the ED. For an overview of all hypotheses, see Figure 3.

3. Method

The research was conducted in collaboration with an ED of a medium-sized (477-bed) hospital. The study was reviewed and approved by the Institutional Review Board and conducted in accordance with the Declaration of Helsinki (Approval numbers: 0010-16-CMC and 0225-20-CMC). We deployed MyED in the ambulant adult section of the ED. This ED treats all disciplines except maternity and otolaryngology cases (those are treated in designated EDs). The adult section is divided into three subsections: ambulant (triage score 3–5), lying-in (triage score 2–3), and trauma (triage score 1). From time to time it occurs that a patient arriving to the ED is rated '1' or '2' (rather than 3–5).

3.1. Participants and Procedure

We ran a field study to test how PIOT affects attitudes and behaviors of people arriving to the ED. The target sample varied according to the outcomes we looked at: (1) people's attitudes (H1–5) were recorded in surveys, resulting in 720 participants (Age *mean*=48 years, *SD*=19; *range*=18–95 years, 52% female). We excluded 43 participants (6%, 11 with time to survey above 96 hours—see below—and 32 with missing survey item values for more than one predicted outcome). Depending on outcome, we had to further exclude participants due to missing survey items. Hence, regarding each outcome, our final survey sample varied between 677 and 662 participants. (2) Patients' abandonment (H6) was recorded in the EMRs, resulting in 18,629 participants (Age *mean*=50 years, *SD*=19; *range*=18–99 years, 51% female). We excluded 403 participants (2%, with less than three process elements in the ED, see Figure 1). Hence, final EMR sample was 18,226 participants. While attitudes of both patients and family members were recorded in the survey, only abandonment of patients (and not family members) was recorded in the EMRs. Hence, we refer to *people's* attitudes and *patients'* abandonment.

All data was collected either during 07/2019–02/2020 (Period I) or during 03–07/2021 (Period II). (We had to stop data collection due to the COVID-19 pandemic in 03/2020, and could resume it only a year later, in 03/2021, due to regulations that limited access to the ED.) Upon arrival, receptionists added people's phone number to the hospital database, which automatically transferred their information to the MyED database. People were informed about the new system as part of the regular ED registration process with the explanation that "MyED is a system that provides you with personal information about anticipated treatment stages and waiting times during your ED visit." Within a few minutes, they received a text message including a link to sign up for MyED. Once they clicked on the link, they could log in with the patient's details on a secured web page. They could easily return to and use MyED throughout their entire ED stay. Once the patient was discharged or hospitalized, the information was not accessible anymore. The architecture of MyED is based on a demilitarized zone (DMZ) server that is separate from the EMR; people have access to the DMZ server only, and it is thus more secure. MyED (see Figure 2) displays only operational and time-related information for each stage the patient encounters during the ED journey; it does not display any medical information. To ensure inclusion of the various populations visiting the ED, the system was offered in four languages: Hebrew, Arabic, Russian, and English. MyED was developed to support four PIOT display modes that differed in the type and amount of information provided about the next stages (i.e., the left screen in Figure 2). The display details are as follows:

- "Display Mode 1" included only basic operational information about the current stage under the label "Now–waiting for". People could see the name and location of the stage, including a map of how to get to that location from the ED.
- "Display Mode 2" included operational information for both current and future stages (under the label "Later"); every stage displayed the same details as in Display Mode 1.
- "Display Mode 3" included basic operational information as in 1, as well as time information for the current stage (e.g., "Between 10-30 minutes"), and for the overall stay in the ED (e.g., "Elapsed time: 3:40 hours, expected time: 7:35 hours").
- "Display Mode 4" provided full information by combining Display Modes 2 and 3. Hence, operational and time information was provided for current and future stages.

Depending on the week people arrived to the ED, we assigned them to one of the four PIOT display modes described above; see also Table 1.

Table 1 PIOT Display Modes and Experimental Conditions

Display Mode	Description	System Use	Type of Information
1	Basic information (i.e., current and completed stages)	Yes	Operational-only information
2	Basic information and future stages	Yes	Operational-only information
3	Basic information and wait times	Yes	Operational and time information
4	Full information	Yes	Operational and time information
-	No information (control condition)	No	No information

We ran the four PIOT display modes one after another in a repeating, two-week cycle. We originally aimed to test the effect of the four display modes (each including a different amount of information, see Table 1—Column 2 'Description'). Due to the COVID-19 pandemic, we did not reach the required sample size for each of the four display modes to support this analysis. Hence, the four above display modes were combined to one or two experimental conditions, depending on the level of analysis: (1) Comparison of *System Use*: "system use" (originally Display Modes 1–4) vs. "no system use"; (2) Comparison of *Type of Information*: "operational-only information" (originally Display Modes 1 and 2) vs. "operational and time information (originally Display Modes 3 and 4) vs. "no information" (no system use). Some people who arrived to the ED did not receive any text message to sign up, due to technical issues (e.g., with the server), and could not use MyED. We refer to this group as the "no information" ("no system use") condition and used it as a natural control group. These people were not exposed to MyED and hence could not be affected by the information provided. This group is different from people who actively decided not to use MyED due, for example, to pain or lack of interest; these people were not part of the study. We recorded in both the survey and the MyED database if a person used MyED or not.

During Period I, research assistants approached the people in the ED while they were waiting for treatment. During Period II, research assistants called people 24–96 hours after their ED visit, for a follow-up; they were not yet allowed to re-enter the ED due to COVID-19 restrictions. We asked people—regardless of whether they (had) used MyED or not—to fill out a short survey about the quality of ED service. The survey contained items to measure people's attitudes (e.g., sense of understanding, sense of progress, and satisfaction), demographic information, and other control variables (see Table 3, Source: Survey). Patients' abandonment from the ED was retrieved from the EMRs. We also retrieved additional control variables from both the EMRs and the MyED database (see Table 3, Source: EMR, MyED).

3.2. Measures

People's attitudes. Table 2 provides an overview of the items and statements we used in the survey to measure people's attitudes. All items were measured on a Likert scale from "1–I totally disagree" to "7–I totally agree".

Table 2 People's Attitudes: Measures and Reliability

Construct	Item	Statement	Source	CA
Sense of Understanding	SU1	I understand the sequence of stages of treatment we have.	*developed in collaboration with hospital managers*	0.94
	SU2	I understand the various stages of treatment we have.		
Sense of Progress	SP1	I feel I am progressing to meet our needs in the ED.	Holman et al. (2007)	0.96
	SP2	I feel our ED service is not moving (reversed).		
Satisfaction	S1	The timeframe of the various stages of treatment is acceptable to me.	Larsson and Larsson (2002)	0.74
	S2	I am familiar with the caregiving team.		
	S3	I was given useful information about the stages we are undergoing.		

Notes. CA=Cronbach's alpha

Patients' abandonment. We measured abandonment with a binary variable coded as "one" (1) when a patient left the ED before finishing treatment or "zero" (0) when the patient finished treatment in the ED. If the patient did not show up when called or return at a later stage, the physician or reception staff entered into the EMR that the patient abandoned the ED; thus, it is known by the end of the day that the patient abandoned.

Other variables of interest. In the survey, we also measured people's attitudes of trust in the hospital and anxiety, and aggressive tendencies of others in the ED. We report on these measures and the findings in the Electronic Companion (EC) document (see Section EC.1.2.2).

Control variables. For an overview of the control variables (i.e., constructs, definition, and source), see Table 3.

ED environment measures—including ED load, proportion of elderly, and proportion of urgent patients—were calculated according to the time (hour) of arrival at the ED. In Period I, the anonymous survey did not include the patient's ID; hence, we were not able to record people's exact time of arrival. We instead relied on information recorded in the survey. We subtracted the time a person estimated they had already spent in the ED (i.e., perceived length of stay [LOS]) from the time the survey was filled out (i.e., survey time) and used it as a proxy for the patient's arrival time.

ED load was defined as the number of patients registered to the ED at the time of arrival of patient i to the ED.

The *proportion of elderly* patients was defined as the proportion of patients above age 65 registered to the ED at the time of arrival of patient i to the ED.

The *proportion of urgent* patients was defined as the proportion of patients with triage score 1–3 registered to the ED at the time of arrival of patient i to the ED.

Person-dynamic measures included patient-level measures recorded in the MyED database during the patient's ED visit—LOS, wait time, and number of stations—and measures recorded from the survey—perceived LOS and time to survey.

LOS was defined as the time from arrival at the ED until the time the patient left the ED (due to discharge, hospitalization, or abandonment). Since we do not know the exact time of abandonment, LOS for abandoning patients was approximated by the patient's arrival time until the end of the wait time for the last stage recorded in the EMRs.

The actual *wait time* regarding each medical procedure j was recorded throughout the patient ED journey in the MyED database. We focused on the wait time regarding the patient's initial (or first) procedure (most likely either a checkup with a nurse or a physician) (i.e., $\textit{wait time}_1$).

Number of stations was the number of procedures that were recorded in the MyED database for each patient during the entire ED stay. This includes, for example, blood tests, imaging, and nurse and physician visits.

Perceived LOS, defined as the time from arrival at the ED until the time the survey was filled out, was recorded at the time the survey was provided. To approximate *time to survey* for Period I, we used perceived LOS. In Period II, time to survey was calculated from the time the patient arrived at the ED until they were called for a follow-up and requested to answer the survey.

Person-static measures included any measure that did not change over the course of the patient's stay in the ED or did not depend on the time they filled out the survey. These control measures included the patient's triage score, whether the survey was completed by a patient or by an accompanying family member, age, gender, education, and whether the survey was filled out independently or read out loud by a research assistant. Roughly 15% of the participants did not report their level of education in the survey. As a proxy for the missing values, we used the average (e.g., 13 years).

For a follow-up analyis, we also calculated *expected wait time*, *expected LOS*, and the accuracy of these two estimates (*accuracy expected wait time*, *accuracy expected LOS*) (to see if these factors moderate the effect of PIOT on patients' abandonment. We report on the measures and results in the EC (Section EC.1.2.1).

Table 3 Control Variables: Measures and Database

Construct	Definition	Database
ED environment measures (average per hour; at ED arrival hour)		
ED load	Number of patients registered in ED	EMR
Proportion of elderly	Proportion of patients above 65 years registered in ED	EMR
Proportion of urgent	Proportion of patients with triage score 1–3 registered in ED	EMR
Person-dynamic measures		
LOS	Time patient stayed in ED in total	EMR
Wait $time_1$ (initial)	Time passed until first procedure	MyED
Number of stations	Number of completed procedures	EMR
Perceived LOS	Time people feel they already spent in ED	Survey
Time to survey	Time passed between ED arrival and survey time	Survey/EMR
Person-static measures (one-time measure)		
Triage score	Evaluation of urgency at ED arrival:	EMR
	very high (1), high (2), moderate (3), low (4), very low (5), not-defined (0)	EMR
Participant type	Person who filled out survey: Patient (1) or family member (0)	Survey
Read to	Research assistant read survey to participant: yes (1) or no (0)	Survey
Age	Age in years	EMR/Survey
Gender	Male (1) or female (0)	EMR/Survey
Education	Number of years of education	Survey
Time measures (according to ED arrival time)		
Period	2019-2020: survey during ED process (1) or 2021: survey after ED process (0)	Survey
Time of day	0:00–5:59 am (1), 6:00-11:59 am (2), 12:00–5:59 pm (3), 6:00–11:59 pm (0)	EMR
Weekday	Sunday (1), Monday (2), Tuesday (3), Wednesday (4), Thursday (5), Friday (6), Saturday (0)	EMR

Notes. EMR = Patient electronic medical record; MyED = System of Personalized Information about Operations and Time (PIOT)

3.3. Statistical Specification for Hypothesis Testing

To test our hypotheses on the effect of PIOT on people's attitudes (H1–5) and on patients' abandonment (H6), we looked at the following two levels of analysis (see also Table 1):

1. Overall effect of MyED *System Use* (system use vs. no system use; regardless of the type of information provided in MyED)

2. Effect of *Type of Information* (operational-only information vs. operational and time information vs. no information)

Effect of PIOT on people's attitudes: To test Hypotheses 1–5, we used the survey sample (N=677). We added period as a moderator to see if participants' responses varied according to the different data collection methods we used in the two periods (i.e., survey provided during vs. after ED journey).

We controlled for ED environment measures (i.e., ED load, proportion of elderly and urgent patients). Overloaded service systems result in long wait times and queues, known to reduce customers' sense of progress and satisfaction (Bielen and Demoulin 2007, Dahm et al. 2018). In particular, when the ED is overloaded, medical staff do not have time to provide explanations about the ED journey. Hence, we expect ED load to also influence people's sense of understanding. Further, because we could not connect the survey data in Period I to the EMRs, we could not control for (overall) wait time. Instead, we used the ED environment measures; ED overload could be caused by a high number of patients that require special attention (elderly or urgent). As another proxy for (overall) wait time, we used perceived LOS.

Besides perceived LOS, we controlled for additional variables recorded in the survey (i.e., time to survey, participant type, read to, age, gender, education), as well as for time of day and weekday. We could not control for patients' triage score, because we could not connect survey data to EMR for people who did not use MyED during Period I.

To test Hypotheses 1, 2, and 4 (main effect of PIOT on people's attitudes), we ran a moderation analysis (model no. 1, Hayes 2017) regarding each predicted outcome (i.e., sense of understanding, sense of progress, satisfaction) on both levels of analysis (i.e., effect of system use, effect of type of information). Given a significant main effect (of system use and/or type of information), we additionally ran a moderated mediation analysis (model no. 8, Hayes 2017) to test Hypotheses 3 and 5 (mediation effect of sense of understanding and sense of progress).

Effect of PIOT on patients' abandonment: To test Hypothesis 6, we used the EMR sample (N=18,226). We again included period, but this time as a control variable (not as a moderator—most of our sample did not respond to the survey, hence we were not interested in any moderating effect of the data collection method. Still, data was collected during COVID-19 pandemic, and attitudes towards medical staff and healthcare services might have changed between the two periods, hence we included it as a control variable.)

Patient abandonment in EDs is affected by the number of people present (Batt and Terwiesch 2015), hence we include ED load as a control variable. In addition, the proportion of elderly and urgent patients—also associated with overloaded systems—are included as control variables. Next, the beginning of the wait is known to influence abandonment (Akşin et al. 2016), and initial delay announcements have been shown to have a strong effect on abandonment (Mandelbaum and Zeltyn 2013). We therefore included the wait time for the first ED procedure the patient went through (most likely a checkup with a nurse or a physician), as a control variable.

We expected patients who go through many procedures to be less likely to abandon, either because this is associated with a more problematic medical condition, or due to sunk cost, the time the patient already invested during the ED journey. To control for these effects, we included the patient's LOS, number of stations, and triage score.

Finally, we controlled for the other variables recorded in EMR and MyED, like age, gender, and time variables. We could not control for the variables only recorded in the survey, because a large part of the sample did not respond to the survey.

To test Hypothesis 6 (effect of PIOT on patients' abandonment), we ran a logistic regression analysis for both levels of analysis (i.e., effect of system use, effect of type of information). In a follow-up analysis, we additionally included the following four variables as moderators to the effect of PIOT on patients' abandonment: expected wait time, accuracy of expected wait time, expected LOS, and accuracy of expected LOS (for measures and results, see Section EC.1.2.1).

4. Results

We ran a factor analysis to ensure that the survey items we used reflect the study variables, in line with theory. For the results, see Section EC.1.1.1. For an overview of the correlations between the study variables, see Section EC.1.1.2. For a short profile of MyED users, see Section EC.1.1.3.

MyED allowed people to receive Personalized Information about Operations and Time (PIOT), and we tested our hypotheses on two levels of analysis, one more general and one more granular: (1) Effects of *System Use* (of MyED), and (2) effects of *Type of Information* (as provided in MyED: operational-only or operational and time information). In the following, we provide results for all hypotheses on the effect of PIOT on people's attitudes and patients' behavior regarding both these levels of analyses.

4.1. Effect of PIOT on People's Sense of Understanding (H1)

Effect of system use. Using MyED increased people's sense of understanding, $F(15,661) = 3.659, R^2 = 0.077, p < 0.001$, see Table 4. We found a significant interaction of system use and period ($p = 0.037$): When people used MyED, their sense of understanding increased only in Period I; that is, when they responded to the survey while they were in the ED ($Mean = 5.49, SD = 1.49$ vs. $Mean = 4.79, SD = 1.79, p = 0.004$). In Period II—when people responded up to 96 hours after the ED visit—system use did not increase people's sense of understanding ($Mean = 5.96, SD = 1.73$ vs. $Mean = 6.07, SD = 1.69,\ p = 0.905$).

Effect of type of information. The type of information provided in MyED predicted people's sense of understanding, $F(19,642) = 58.358, R^2 = 0.633, p < 0.001$, see Table 5. In particular, both operational-only and operational and time information increased people's sense of understanding ($p = 0.028$ and $p = 0.001$, respectively), compared to if no information was provided. To see if operational and time information also increased sense of understanding compared to operational-only information, we re-coded type of information and reran the analysis. We found that operational and time information marginally increased people's sense of understanding compared to operational-only information ($p = 0.090$).

Table 4 Effect of System Use on People's Attitudes

	OUTCOME					
	S. of Understand.		S. of Progress		Satisfaction	
	coeff	*se*	*coeff*	*se*	*coeff*	*se*
Constant	4.17***	0.84	5.03***	0.87	2.84***	0.86
System use	1.25**	0.48	0.53	0.50	0.28	0.49
Period	1.29***	0.31	0.83*	0.32	1.71***	0.32
System use × period	-0.61*	0.29	-0.29	0.30	-0.14	0.30
ED load	-0.03*	0.01	-0.02†	0.01	-0.03***	0.01
Proportion of elderly	-0.20	0.44	0.22	0.46	0.75	0.46
Proportion of urgent	0.20	0.33	0.35	0.34	0.18	0.34
Perceived LOS	0.00*	0.00	0.00***	0.00	0.00***	0.00
Time to survey	-0.01†	0.00	-0.01	0.01	-0.01**	0.00
Participant type	0.01	0.17	-0.06	0.18	-0.19	0.19
Read to	-0.16	0.18	-0.58**	0.19	0.05	0.19
Age	0.01*	0.00	0.00	0.00	0.00	0.00
Gender	0.07	0.13	-0.21	0.13	-0.13	0.13
Education	-0.02	0.02	0.00	0.02	-0.04†	0.02
Time of day	*included*		*included*		*included*	
Weekday	*included*		*included*		*included*	
N	677		674		672	
R^2	0.077		0.115		0.194	
Adj. R^2	0.055		0.093		0.174	
Residual Std. Error	2.646		2.825		2.756	
F Statistic (df)	3.659*** (15,661)		5.715*** (15,658)		10.530*** (15,656)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

There was a (marginally) significant interaction of type of information and period ($p = 0.081$ and $p = 0.005$, respectively): Operational-only information increased people's sense of understanding in Period I ($Mean = 5.35, SD = 1.59$ vs. $Mean = 4.79, SD = 1.79, p = 0.015$), but not in Period II ($Mean = 5.88, SD = 1.86$ vs. $Mean = 6.07, SD = 1.69$, $p = 0.938$). Similarly, operational and time information increased people's sense of understanding in Period I ($Mean = 5.73, SD = 1.27$ vs. $Mean = 4.79, SD = 1.79, p < 0.001$), but not in Period II ($Mean = 6.01, SD = 1.65$ vs. $Mean = 6.07, SD = 1.69$, $p = 0.826$).

Together, Hypothesis 1 was fully supported: PIOT improved people's sense of understanding about their ED journey, regardless of the specific information provided. Still, providing time information together with operational information yielded higher understanding of ED processes than providing only operational information.

4.2. Effect of PIOT on People's Sense of Progress (H4)

Effect of system use. Contrary to expectation, using MyED did not increase people's sense of progress ($p = 0.288$), $F(15, 658) = 5.715, R^2 = 0.115, p < 0.001$—in neither of the two periods, as the non-significant interaction of system use and period ($p = 0.349$) shows (see Table 4).

Effect of type of information. However, the type of information provided in MyED predicted people's sense of progress, $F(17, 644) = 5.248, R^2 = 0.122, p < 0.001$, see Table 5). Specifically, while providing operational-only information was not enough to increase people's sense of progress, operational and time time information marginally increased it ($p = 0.729$, $p = 0.079$, respectively). To see if operational and time information also increased people's sense of progress compared to operational-only information, we re-coded type of information and reran the analysis. We found that operational and time information marginally increased people's sense of progress, compared to operational-only information ($p = 0.094$).

The effect of type of information on people's sense of progress did not vary between Period I and II ($p = 0.914$ and $p = 0.116$, respectively).

In sum, Hypothesis 4 was partly supported: PIOT slightly improved people's sense of progress about their ED journey, but only if both operational and time information was provided.

4.3. Effect of PIOT on People's Satisfaction (H2)

Effect of system use. Contrary to expectation, using MyED did not increase people's satisfaction ($p = 0.568$), $F(15, 656) = 10.530, R^2 = 0.194, p < 0.001$—neither in Period I nor in Period II, as the non-significant interaction of system use and period ($p = 0.638$) shows (see Table 4).

Effect of type of information. However, the type of information provided in MyED predicted people's satisfaction, $F(19, 642) = 58.358, R^2 = 0.633, p < 0.001$; see Table 5. In particular, while providing operational-only information was not enough to increase people's satisfaction, providing both operational and time information was ($p = 0.671$ and $p = 0.049$, respectively). To see if operational and time information also increased people's satisfaction compared to operational-only information, we re-coded type of information and reran the analysis. We found that operational and time information marginally increased people's satisfaction, compared to operational-only information ($p = 0.063$).

There was a (marginally) significant interaction of type of information with period ($p = 0.560$ and $p = 0.078$): Operational and time information increased people's satisfaction in Period I ($Mean =$

$4.30, SD = 1.35$ vs. $Mean = 3.87, SD = 1.72, p = 0.048$) but not in Period II ($Mean = 5.05, SD = 1.83$ vs. $Mean = 5.30, SD = 1.85, p = 0.861$).

Taken together, Hypothesis 2 was partly supported: PIOT improved people's satisfaction with ED service, but only if time information was provided alongside the operational information.

4.4. Mediating Effect of Sense of Understanding (H3) and Sense of Progress (H5)

Effect of system use. As already stated, using MyED did not increase people's satisfaction. Hence, we could not run a mediation analysis to see if increases in people's sense of understanding and sense of progress explain the effect of people's system use on (improved) satisfaction.

Effect of type of information. In Section 4.1 we learned, that both operational-only and operational and time information increased people's sense of understanding. Further, operational-only information did not increase people's sense of progress, while operational and time information marginally increased it (see Section 4.2). The increased sense of understanding and progress resulted in people's increased satisfaction ($p < 0.001$ and $p < 0.001$, respectively), see Table 5.

People's sense of understanding mediated the effect of type of information on people's (improved) satisfaction (operational-only information: $\beta = 0.06$, $SE = 0.09$ $CI = 0.05, 0.43$; operational and time information: $\beta = 0.42$, $SE = 0.11$, $CI = 0.21, 0.65$). Hence, Hypothesis 3 was fully supported: PIOT increased people's satisfaction with ED service through an increased sense of understanding, regardless of whether or not time information was provided.

However, people's sense of progress only mediated the effect of operational and time information ($\beta = 0.20$, $SE = 0.10$, $CI = 0.01, 0.40$), not of operation-only information ($\beta = 0.06$, $SE = 0.09$, $CI = -0.12, 0.24$) on people's satisfaction. Hypothesis 5 was partly supported: PIOT increased people's satisfaction with ED service through an increased sense of progress—but only if time information was provided besides the operational information.

4.5. Effect of PIOT on Patients' Abandonment (H6)

Effect of system use. Besides people's attitudes, we were interested in the effect of system use on patients' likelihood to abandon the ED (before finishing ED service). Whether patients used MyED or not did not affect their likelihood to abandon ($p = 0.272$), $X^2(24) = 202.365, R^2 = 0.047, p < 0.001$ (see Table 6, left side).

Effect of type of information. However, the type of information provided in MyED predicted patients' likelihood to abandon, $X^2(25) = 205.839, R^2 = 0.048, p < 0.001$ (see Table 6, right side).

Specifically, providing operational-only information reduced patients' likelihood to abandon by 26.67% (from 3% to 2.2%) ($p = 0.049$). Still, providing operational and time information did not reduce patients' likelihood to abandon ($p = 0.592$).

Table 5 Effect of Type of Information on People's Attitudes: Mediation of Sense of Understanding and Sense of Progress

	MEDIATORS				OUTCOME	
	S. of Understand.		S. of Progress		Satisfaction	
	coeff	*se*	*coeff*	*se*	*coeff*	*se*
Constant	3.73^{***}	0.86	4.94^{***}	0.88	-1.24^{*}	0.61
Type of information						
- operational-only	1.16^{*}	0.53	0.19	0.54	$-0.64^{\dagger}$	0.36
- operational and time	2.00^{***}	0.58	$1.04^{\dagger}$	0.59	0.10	0.40
S. of understanding					0.53^{***}	0.04
S. of progress					0.34^{***}	0.04
Period	1.45^{***}	0.32	0.89^{**}	0.33	0.92^{***}	0.22
Type of info. $\times$ *period*						
- operational-only $\times$ period	$-0.59^{\dagger}$	0.34	-0.04	0.35	0.37	0.23
- operational and time $\times$ period	-0.98^{**}	0.35	-0.56	0.36	-0.03	0.24
ED load	-0.03^{*}	0.01	-0.02^{*}	0.01	-0.02^{*}	0.01
Proportion of elderly	-0.10	0.46	0.21	0.47	0.69^{*}	0.31
Proportion of urgent	0.17	0.33	0.44	0.34	-0.08	0.23
Perceived LOS	0.00^{*}	0.00	0.00^{***}	0.00	0.00^{*}	0.00
Time to survey	-0.01^{*}	0.00	0.00	0.00	0.00	0.00
Participant type	0.00	0.17	-0.08	0.18	-0.18	0.12
Read to	-0.04	0.19	-0.52^{**}	0.20	0.46^{***}	0.13
Age	0.00	0.00	0.00	0.00	0.00	0.00
Gender	0.07	0.13	-0.21	0.13	-0.05	0.09
Education	-0.02	0.02	0.00	0.02	-0.03^{**}	0.01
Time of day	*included*		*included*		*included*	
Weekday	*included*		*included*		*included*	
N	662		662		662	
R^2	0.085		0.122		0.633	
Adj. R^2	0.059		0.097		0.622	
Residual Std. Error	2.671		2.809		1.263	
F Statistic (df)	3.522^{***} (17,644)		5.248^{***} (17,644)		58.358^{***} (19,642)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

Hypothesis 6 was partly supported: PIOT reduced patients' likelihood to abandon, but only if no time information was provided. We present a follow-up analysis in the EC (see Section EC.1.2.1) showing partly why there is no positive effect of providing time information: If a patient's expected LOS in the ED was long, providing time information *in*creased, rather than *de*creased the likelihood of abandonment!

5. Discussion

5.1. Summary of Results

In this work, we report on a field study that tested a system of *Personalized Information about Operations and Time* (PIOT)—called MyED—in a medium-sized hospital. MyED reports to individual patients and family members a frequently updated list of completed, ongoing, and planned procedures, along with anticipated wait times. The displayed information thus reveals previously unknown elements of the individual patient journey.

Table 6 **Effect of System Use and Type of Information on Patients' Abandonment**

	OUTCOME: Abandonment			
	System use		Type of info.	
	coeff	*se*	*coeff*	*se*
Constant	-3.74***	0.71	-3.74***	0.71
System use	-0.13	0.12		
Type of information				
- operational-only			-0.32*	0.16
- operational and time			0.08	0.16
Period	-0.46***	0.10	-0.44***	0.10
ED load	0.02**	0.01	0.02**	0.01
Proportion of elderly	0.37	0.37	0.35*	0.37
Proportion of urgent	0.11	0.25	0.09	0.25
Wait time	0.00	0.00	0.00	0.00
LOS	0.00***	0.00	0.00***	0.00
Number of stations	-0.13***	0.02	-0.14***	0.02
Triage score	*included*		*included*	
Age	0.00	0.00	0.00	0.00
Gender	-0.17†	0.09	-0.17†	0.09
Time of day	*included*		*included*	
Weekday	*included*		*included*	
N	18,226		18,226	
Nagelkerke R^2	0.047		0.048	
-2 Log Likelihood	4634		4631	
AIC	4682		4681	
X^2	202.365*** (24)		205.839*** (25)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

We find that PIOT affects patients' and family members' attitudes *during* the ED visit. In particular, PIOT increased people's sense of understanding and of progress about the patient's ED journey, resulting in increased satisfaction with ED service. The effect depended on the type of information: while both operational-only information and operational and time information increased people's sense of understanding, the effect of the latter type was stronger, and operational-only information did not help increase people's sense of progress.

Interestingly, when people were questioned *after* their ED visit (i.e., 24–96 hours following it), their attitudes were overall more positive. As this improvement in attitudes regards both the MyED system users and non-users, all previously reported effects disappear. These results are consistent with the end rule, which states that customers remember endings more vividly than beginnings. Accordingly, Bray (2020) showed that transportation companies should emphasize last-mile logistics, as the last mile is the most memorable mile. The peak-end rule should apply to most service operations. For example, Redelmeier et al. (2003) showed that adding a needless resting period to the end of a colonoscopy improved patient impressions of the procedure. In our study, in Period II, patients had already been released from the ED, after receiving diagnosis and treatment for their medical problem. Hence, they were more likely to feel better when asked to respond to the survey. In addition, at that stage, they had already gone through the whole ED process, acquiring a better understanding of what ED service entails. Thus, it should not come as a surprise that post-service evaluations were higher in our study than service evaluations made during the ED journey.

Besides improving people's attitudes, PIOT reduced an important behavioral outcome in hospitals: patients' abandonment from the ED. The effect again depended on the type of information: operational-only information reduced the likelihood of patients abandoning by 26.67% (from 3% to 2.2%). This is a huge reduction, showing the importance of providing transparency about the process during service delivery. Interestingly, patients were not less likely to abandon if they additionally received time information. In a follow-up analysis (see Section EC.1.2.1), we provide initial evidence for why this effect occurs: The longer the patient is expected to stay in the ED—as displayed in MyED—the more providing time information increased (rather than reduced) patients' abandonment! This finding is in line with previous research showing that customers react negatively to the service if delay information is inaccurate (Armony et al. 2009). Following the announcement of an inaccurately short delay, customers perceive the service provider as less reliable and abandon more (Mandelbaum and Zeltyn 2013). In a hospital study where ED patients were presented with a flow chart describing procedures typically encountered during an ED journey along with expected wait times, Efrat-Treister et al. (2020) showed that this information is problematic once patients face long waits. In sum, future research should continue to explore the optimal means for presenting time information to ED patients.

5.2. Limitations and Future Research

In the current work we followed the call for more "carefully designed prospective field studies" in empirical research in healthcare operations (p.80 Kc et al. 2020). Due to the COVID-19 pandemic and resulting restrictions in accessing the hospital ED, we were forced to conduct the field study in two separate parts. As a result, the data collection method in Period I and II differed (i.e., survey provided during vs. after ED process). We found significant differences in people's attitudes in Period I and II. Together with the overall improved attitudes in Period II (regardless of MyED use), it seems that people failed to recall their negative experience in the ED (likely due to stress, pain, and helplessness) a few days after their ED journey ended. All they might remember is that their medical problem has been solved. While this explanation seems logical for the differences in people's attitudes in Period I and II, we need to consider other possible explanations: Between Period I (2019–2020) and Period II (2020–2021), one year passed. Hence, the COVID-19 pandemic (before vs. after lockdowns), the differing season, or other external changes in the environment may explain the differences we found in people's attitudes during and after the ED visit. A follow-up study should investigate this to disentangle the various effects.

Apart from the split data collection, the cohort of MyED users may reflect a selection bias. Research assistants were instructed not to approach patients in great pain. Even regardless of that, low system adoption among people who feel sick or are in pain remains a challenge, as well as among those who are technologically illiterate. In addition, our control group comprised people who did not receive any text message to sign up to MyED. In the (EMR) sample we used for testing the effect of PIOT on patients' abandonment ($N = 18,226$), some of the text messages were not sent due to technical issues; these people could not use MyED even if they wanted to, and hence comprised a natural control group. Still, in the (survey) sample we used to test for the effect of PIOT on people's attitudes ($N = 677$), we can only assume that the people who reported that they did not receive any text message indeed did not. Future research should address this issue by taking potential biases such as technological illiteracy into account.

Next, future research could examine staffing-related controls in the effect of PIOT on patients' abandonment (Kc et al. 2020). The number of medical providers has shown to predict wait times (Ang et al. 2016, Ibrahim 2018). Recent research has revealed that an estimate of the patients' rate of departure from a specific (treatment) stage can be used instead of the number of medical providers (multiplied by the time at the stage) to predict wait times (Carmeli et al. 2022). In the current work, we controlled for ED load and the wait time as perceived by the specific patient. However, we did not not have access to the (number of) medical providers. Literature suggests that the particular medical team and the familiarity between team members are also important factors in productivity and job performance (Muskat et al. 2022, Janss et al. 2012). Future research should consider these and other staffing-related controls, when testing for the effect of PIOT on patients and family members.

Lastly, we only deployed and tested MyED in the ambulant adult ED of one specific hospital. Patients in the lying-in unit, or in the same units in smaller or larger hospitals, may have needs that were not identified in this research. This should be taken into account when implementing a system of PIOT in a hospital ED.

5.3. Theoretical Contributions

We contributed to research on operational transparency (cf. Buell et al. 2017, 2020), delay announcements (cf. Ibrahim et al. 2017), and personalized information (e.g., Drakopoulos et al. 2021). Specifically, we integrated these three bodies of research and used signaling theory (cf. Spence 2002, Connelly et al. 2011) to show that all three types of information provision represent a signal for service quality in ED service. In other words, operational transparency in a personalized format, with delay announcements embedded, is an effective tool to communicate to people (here: patients and family members) that the organization (here: hospital) cares and makes an effort for them to understand the elements of their personal ED journey; information that commonly remains hidden.

5.4. Managerial Implications

An information system such as the one presented here—MyED, revealing procedures and anticipated wait times for the individual patient—addresses typically overlooked psychological needs of people in EDs for information and understanding. MyED responds to people's needs with minimal disruption to the ED workflow as it relies on available information directly extracted from EMR that medical staff routinely update. Patients merely receive process and time-related information; they are not provided with the actual test results or other concrete medical information. In sum, providing Personalized Information about Operations and Time (PIOT) to patients and accompanying family members during the ED journey offers a novel approach to improving healthcare service.

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EC.1. Appendix

EC.1.1. Descriptive Analyses

EC.1.1.1. Factor Analysis. We conducted an exploratory factor analysis to verify the independence of the constructs in our model. The results are reported in Table EC.1, based on the data collected in Periods I and II ($N = 672$) (we excluded four participants due to missing values regarding one or more of the outcomes). We assumed correlations between the constructs and hence chose an oblique rotation with a cut-off value for loadings at 0.5.

The analysis identified six factors, in line with our theory, with the six factors explaining 88% of the variance. For an overview of the survey items, see Table 2. Factor 1 (Sense of Progress) comprised the two sense of progress items, which explained 17% of the variance. Factor 2 (Sense of Understanding) comprised the two sense of understanding items, which explained 16% of the variance. Factor 3 (Trust) comprised the two trust items, which explained 15% of the variance. Factor 4 (Anxiety) comprised the two anxiety items, which explained 14% of the variance. Factor 5 (Aggressive Tendencies) comprised the two aggressive tendencies items, which explained 13% of the variance. Lastly, Factor 6 (Satisfaction) comprised two of the three satisfaction items, which explained 13% of the variance. Following this, we excluded one satisfaction item (S3) from the statistical analyses, as it did not meet the threshold value of 0.5.

Table EC.1 Factor Analysis—Promax: People's Attitudes and Aggressive Tendencies

		Factors					
		F1	**F2**	**F3**	**F4**	**F5**	**F6**
Item		**SP**	**SU**	**T**	**A**	**AG**	**S**
1	SP1	**1.00**	0.06	-0.01	0.01	0.00	-0.10
2	SP2	**0.95**	0.10	0.01	0.02	0.03	-0.06
3	SU1	0.13	**0.92**	-0.02	-0.01	-0.01	-0.07
4	SU2	-0.02	**0.91**	0.01	0.02	-0.03	0.06
5	T2	-0.03	0.00	**0.99**	-0.02	0.01	-0.02
6	T1	0.04	0.00	**0.95**	0.02	-0.02	0.00
7	A1	0.02	0.01	-0.01	**0.96**	-0.03	0.01
8	A2	0.01	-0.01	0.01	**0.95**	0.02	0.03
9	AG2	0.01	0.05	-0.04	-0.04	**0.94**	-0.01
10	AG1	0.01	-0.08	0.04	0.04	**0.91**	0.02
11	S2	-0.20	0.09	-0.01	0.05	0.02	**1.00**
12	S1	0.42	-0.25	-0.01	-0.05	-0.06	**0.65**
13	S3	0.04	0.41	0.05	-0.04	0.04	0.46
Eigenvalue		2.17	2.08	1.89	1.83	1.72	1.66
%		0.17	0.16	0.15	0.14	0.13	0.13
Cumulative %		0.17	0.33	0.48	0.62	0.75	0.88

Notes. SP=Sense of Progress; SU= Sense of Understanding; T=Trust; A=Anxiety; AG=Aggressive tendencies S=Satisfaction.

EC.1.1.2. Correlations. We determined the relationship between sense of understanding, sense of progress, satisfaction, trust, anxiety, and aggressive tendencies, using Pearson product-moment correlations. There was a strong correlation between all the study variables; see Table EC.2. As expected, all correlations were positive, except the correlations with anxiety and aggressive tendencies.

Table EC.2 Correlations: People's Attitudes and Aggressive Tendencies

		1	2	3	4	5	6
1	Sense of Understanding	1					
2	Sense of Progress	0.587**	1				
3	Satisfaction	0.669**	0.677**	1			
5	Trust	0.508**	0.519**	0.526**	1		
5	Anxiety	-0.120**	-0.195**	-0.183**	-0.145**	1	
6	Aggressive Tendencies	-0.115**	-0.179**	-0.184**	-0.205**	0.149**	1

Notes. All correlations are significant at the $p < 0.01$ level.

EC.1.1.3. Profile of MyED Users. Of the 18,226 people who arrived to the ED either during Period I (07/2019–02/2020) or during Period II (03–07/2021), 26% clicked on the link in the text message to sign up for MyED. 21% tried to enter MyED at least once, and 20% successfully entered MyED. Hence, we lost 6% of those who tried to enter, presumably mostly due to technical problems or technological illiteracy. 42% of those who succeeded to enter used MyED more than once.

Table EC.3 People's Entry Success and Use of MyED

Number of people		Total	1	2	3	4	5
1	arrived to ED	18,226	100%				
2	clicked on link in text message to MyED	4,808	26%	100%			
3	tried to enter MyED	3,780	21%	79%	100%		
4	successfully entered MyED	3,564	20%	74%	94%	100%	
5	entered MyED more than once	1,502	8%	31%	40%	42%	100%

EC.1.2. Additional Results

EC.1.2.1. Effect of PIOT on Patients' Abandonment: Moderating Effect of (Accuracy of) Expected Wait and Expected LOS. We report in Section 4.5 on the effects of PIOT on patients' abandonment. In the analysis, we did not include estimates for expected wait nor for expected LOS, as only MyED users could see this information and be affected by it. However, we suggest the initially (i.e., upon ED arrival) expected wait time and LOS—and the accuracy of these estimates—to have a strong effect on patients' likelihood to abandon, given the patient was provided with PIOT (through MyED). We expect to see higher patience (less abandonment) with longer expected (initial) wait/LOS. And, we expect lower patience (more abandonment) if (initially) expected wait/LOS was inaccurate (especially, if it was underestimated).

We ran logistic regression analyses to test for the following four interaction effects: of PIOT and (1) expected wait time, (2) expected LOS, (3) accuracy of expected wait time, and (4) accuracy of expected LOS. Specifically, we ran two logistic regression analyses (one including (1) and (2), and one including (1)–(4)), for both levels of analysis (i.e., effect of system use and type of information), and included an estimate for the four proposed moderators. We controlled for the same variables as mentioned in Table 3 (regarding the testing of Hypothesis 6). The results can be seen as an extension of the results reported in Table 6 (for convenience also included in Tables EC.5 and EC.6).

We calculated the following variables: For *expected wait time*, we used the first estimate MyED presented regarding the first procedure the patient encountered (i.e., $\textit{expected wait time}_1$). $\textit{Accuracy expected wait time}_1$ was calculated as $(\textit{expected wait time}_1 - \textit{wait time}_1)/\textit{wait time}_1$. Hence, it refers to the deviance of expected and (actual) wait time for the patient's first procedure, in proportion to the (actual) wait time for the patient's first procedure. For *expected LOS*, we used the first estimate MyED presented for the time remaining until ED exit (i.e., $\textit{expected LOS}_1$. $\textit{Accuracy expected LOS}_1$ was calculated as $(\textit{expected LOS}_1 - \textit{LOS})/\textit{LOS}$. Hence, it was the deviance of the patient's initially expected and (actual) LOS, in proportion to (actual) LOS. (The estimates for expected wait time and expected LOS were frequently updated throughout the patient's ED stay).

Table EC.4 Additional Control Variables for Follow-up Analysis: Measures and Database

Construct	Definition	Database
Expected wait time$_1$	Predicted time remaining until next (first) procedure	MyED
Accuracy expected wait time$_1$	Deviance of predicted time remaining until next (first) procedure (from actual) (in %)	MyED
Expected LOS$_1$	Initially predicted time remaining until ED exit	MyED
Accuracy expected LOS$_1$	Deviance of initially predicted time remaining until ED exit (from actual) (in %)	MyED

Results for the moderating effects of expected wait$_1$ and expected LOS$_1$, as well as the accuracy of these two estimates, are displayed in Table EC.5 (effect of system use) and EC.6 (effect of type of information). The main effect of system use remains insignificant ($p = 0.454$), and the main effect of type of information turns insignificant (operational-only information: $p = 0.681$; operational and time information: $p = 0.161$). Still, we can see that the initially expected LOS moderated the effect of both system use and type of information on patients' abandonment: the longer the expected LOS, the more system use marginally increased the likelihood of patients' abandonment ($p = 0.051$, see column 3 "Accuracy" in Table EC.5). Similarly, the longer the expected LOS, the more providing operational and time information marginally increased the likelihood of patients' abandonment ($p = 0.098$, see column 3 "Accuracy" in Table EC.6). Besides expected LOS, neither the expected wait, nor the accuracy of expected wait or of LOS moderated the effect of system use or type of information on patients' abandonment.

Table EC.5 Effect of System Use on Patients' Abandonment: Moderation of Expected Wait Time and LOS, and Accuracy

MODERATORS:	OUTCOME: Abandonment					
	None (Table 6)		Expected		Accuracy	
	coeff	*se*	*coeff*	*se*	*coeff*	*se*
Constant	-3.74***	0.71	-3.98***	0.72	-4.26***	0.70
System use	-0.13	0.12	-0.23	0.30	-0.27	0.34
Period	-0.46***	0.10	-0.38***	0.11	-0.36**	0.11
ED load	0.02**	0.01	0.02**	0.01	0.02**	0.01
Proportion of elderly	0.37	0.37	0.34	0.38	0.34	0.38
Proportion of urgent	0.11	0.25	0.12	0.26	0.11	0.26
Wait time_1	0.00	0.00	0.00	0.00	0.00	0.00
Expected wait_1			0.00	0.01	0.01	0.01
Expected wait_1 × system use			0.02	0.02	-0.02	0.02
Accuracy exp. wait_1					-0.09	0.06
Accuracy exp. wait_1 × system use					-0.08	0.13
LOS	0.00***	0.00	0.00***	0.00	0.00***	0.00
Expected LOS_1			0.00	0.00	0.00	0.00
Expected LOS_1 × system use			0.00†	0.00	0.00†	0.00
Accuracy exp. LOS_1					0.19***	0.04
Accuracy exp. LOS_1 × system use					-0.12	0.12
Number of stations	-0.13***	0.02	-0.14***	0.03	-0.13***	0.02
Triage score	*included*		*included*		*included*	
Age	0.00	0.00	0.00	0.00	0.00	0.00
Gender	-0.17†	0.09	-0.17†	0.09	-0.19*	0.09
Time of day	*included*		*included*		*included*	
Weekday	*included*		*included*		*included*	
N	18,226		18,226		18,226	
Nagelkerke R^2	0.047		0.051		0.058	
-2 Log Likelihood	4634		4618		4590	
AIC	4682		4674		4654	
X^2	202.365*** (24)		218.753*** (28)		246.799*** (32)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

Table EC.6 Effect of Type of Information on Patients' Abandonment: Moderation of Expected Wait Time and LOS, and Accuracy

MODERATORS:	OUTCOME: Abandonment					
	None (Table 6)		Expected		Accuracy	
	coeff	*se*	*coeff*	*se*	*coeff*	*se*
Constant	-3.74***	0.71	-4.00***	0.72	-4.27***	0.70
Type of information						
- operational-only	-0.32*	0.16	-0.02	0.40	-0.20	0.50
- operational and time	0.08	0.16	0.56	0.45	0.67	0.48
Period	-0.44***	0.10	-0.37***	0.11	-0.35**	0.10
ED load	0.02**	0.01	0.02**	0.01	0.02**	0.01
Proportion of elderly	0.37	0.37	0.34	0.37	0.34	0.38
Proportion of urgent	0.11	0.25	0.11	0.26	0.10	0.26
Wait time_1	0.00	0.00	0.00	0.00	0.00	0.00
Expected wait_1			0.00	0.01	0.01	0.01
Expected $wait_1$ $\times$ *Type of info.*						
- Expected wait_1 $\times$ operational-only			0.00	0.02	0.01	0.03
- Expected wait_1 $\times$ operational and time			0.02	0.03	0.02	0.04
Accuracy exp. wait_1					-0.09	0.06
Accuracy exp. $wait_1$ $\times$ *Type of info.*						
- Accuracy exp. wait_1 $\times$ operational-only					-0.14	0.21
- Accuracy exp. wait_1 $\times$ operational and time					-0.05	0.16
LOS	0.00***	0.00	0.00***	0.00	0.00***	0.00
Expected LOS_1			0.00***	0.00	0.01	0.01
Expected LOS_1 $\times$ *Type of info.*						
- Expected LOS_1 $\times$ operational-only			0.00	0.00	0.00	0.00
- Expected LOS_1 $\times$ operational and time			0.00	0.00	0.00†	0.00
Accuracy exp. LOS_1					0.19***	0.04
Accuracy exp. LOS_1 $\times$ *Type of info.*						
- Accuracy exp. LOS_1 $\times$ operational-only					-0.02	0.23
- Accuracy exp. LOS_1 $\times$ operational and time					0.16	0.14
Number of stations	-0.14***	0.02	-0.14***	0.02	-0.13***	0.03
Triage score	*included*		*included*		*included*	
Age	0.00	0.00	0.00	0.00	0.00	0.00
Gender	-0.17*	0.09	-0.18*	0.09	-0.18*	0.09
Time of day	*included*		*included*		*included*	
Weekday	*included*		*included*		*included*	
N	18,226		18,226		18,226	
Nagelkerke R^2	0.048		0.052		0.059	
-2 Log Likelihood	4631		4614		4586	
AIC	4681		4676		4660	
X^2	205.839*** (25)		222.142*** (31)		250.874*** (37)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$

EC.1.2.2. Effect of PIOT on People's Trust, Anxiety, and Aggressive Tendencies. In addition to the presented outcomes of interest, we measured people's trust in the hospital, their anxiety, and aggressive tendencies of others in the ED. We used the measures detailed in Table EC.7, and report in the following on the expected and actual results.

Table EC.7 People's Attitudes: Additional Measures and Reliability

Construct	Item	Statement	Source	CA
Trust	T1	The hospital is an organization that can be trusted at all times.	Morgan and Hunt (1999)	0.94
	T2	The hospital is an organization that is honest and truthful.		
Anxiety	A1	I feel concerned.	Butcher and Spielberger (2014)	0.92
	A2	I feel stressed.		
Aggressive	AG1	It seems to me that someone is about to use offensive language.	Severance et al. (2013)	0.80
Tendencies	AG2	It seems to me that there will soon be yelling around here.	Bushman et al. (1999)	
	AG3	It seems to me that somebody is going to damage hospital property.		

Notes. CA=Cronbach's alpha

People's trust. Similar to attitudes of satisfaction, we expected PIOT to improve people's trust in the hospital. However, system use did not predict people's trust ($p = 0.269$), $F(15,633) = 4.050, R^2 = 0.088, p < 0.001$. Type of information did also not predict people's trust (operational-only information: $p = 0.432$; operational and time information: $p = 0.246$), $F(17,631) = 3.591, R^2 = 0.088, p < 0.001$. The survey items we used to measure people's trust referred to people's general trust in the hospital, rather than situation-specific trust. Presenting PIOT might not have been a strong enough tool to change people's general attitudes toward the service provider.

People's anxiety. Next, we expected PIOT to improve (reduce) people's anxiety in the ED. However, system use did not predict people's anxiety ($p = 0.894$), $F(15,658) = 3.009, R^2 = 0.064, p = 0.003$. And, type of information did also not predict' people's anxiety (operational-only information: $p = 0.809$; operational and time information: $p = 0.445$), $F(17,656) = 2.741, R^2 = 0.067, p < 0.001$. When people are anxious, their level of attention and their ability to process and evaluate information can be greatly reduced (Gino et al. 2012). This might explain why we did not find any effect of PIOT on people's anxiety in the ED.

People's aggressive tendencies. Lastly, we expected PIOT to improve (reduce) people's aggressive tendencies in the ED. We could not measure actual aggression, because people engaging in aggression are usually expelled from the ED. And even if not, they are likely not available to respond to surveys. As a proxy, we measured people's tendency to act with aggression (see Table EC.7), also following Efrat-Treister et al. (2020), Hammock and Richardson (1992).

System use did not predict people's aggressive tendencies ($p = 0.263$), $F(15,663) = 4.416, R^2 = 0.091, p < 0.001$. Similarly, type of information did not predict people's aggressive tendencies (operational-only information: $p = 0.359$; operational and time information: $p = 0.387$), $F(17,661) = 3.944, R^2 = 0.092, p < 0.001$. We assume we did not find any effect of PIOT on people's aggressive tendencies in the ED as people generally felt others showed very little aggressive tendencies in the ED; there was close to no variance in the predicted outcome.

Table EC.8 Effect of System Use on People's Trust, Anxiety and Aggressive Tendencies

	OUTCOME					
	Trust		Anxiety		Aggress. Tend.	
	coeff	*se*	*coeff*	*se*	*coeff*	*se*
Constant	5.19^{***}	0.68	1.64	1.09	2.27^{***}	0.39
System use	0.42	0.38	-0.08	0.62	-0.44	0.39
Period	0.91^{***}	0.25	0.13	0.40	$-0.45^{\dagger}$	0.25
System use × period	-0.17	0.24	-0.15	0.38	0.27	0.24
ED load	-0.00	0.00	0.00	0.02	0.00	0.00
Proportion of elderly	0.18	0.36	-0.14	0.58	-0.26	0.36
Proportion of urgent	-0.17	0.27	-0.98^{*}	0.42	0.25	0.27
Perceived LOS	0.00^{**}	0.00	0.00	0.00	0.00^{***}	0.00
Time to survey	-0.01^{**}	0.00	0.00	0.00	0.01^{**}	0.00
Participant type	0.17	0.14	0.45^{*}	0.22	-0.05	0.14
Read to	-0.29^{*}	0.16	0.15	0.24	-0.01	0.15
Age	0.00	0.00	0.00	0.00	0.00	0.00
Gender	-0.02	0.10	0.54^{**}	0.17	-0.12	0.10
Education	-0.03	0.02	0.02^{*}	0.03	0.01^{*}	0.02
Time of day	*included*		*included*		*included*	
Weekday	*included*		*included*		*included*	
N	649		674		679	
R^2	0.088		0.064		0.091	
Adj. R^2	0.065		0.041		0.069	
Residual Std. Error	1.656		4.453		1.760	
F Statistic (df)	4.050^{***} (15,633)		3.009^{***} (15,658)		4.416^{***} (15,663)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$

Table EC.9 Effect of Type of Information on People's Trust, Anxiety and Aggressive Tendencies

	OUTCOME					
	Trust		Anxiety		Aggress. Tend.	
	coeff	*se*	*coeff*	*se*	*coeff*	*se*
Constant	5.19***	0.69	1.84†	1.11	2.20**	0.69
Type of information						
- operational-only	0.33	0.42	0.16	0.67	-0.39	0.42
- operational and time	0.53	0.46	-0.57	0.73	-0.40	0.46
Period	0.91***	0.25	0.07	0.41	-0.44†	0.25
Type of info. × *period*						
- operational-only × period	-0.09	0.27	-0.29	0.43	0.19	0.27
- operational and time × period	-0.25	0.27	0.10	0.44	0.28	0.28
ED load	0.00	0.00	0.00	0.01	0.00	0.00
Proportion of elderly	0.17	0.36	-0.13	0.58	-0.25	0.36
Proportion of urgent	-0.17	0.27	-1.00*	0.42	0.25	0.27
Perceived LOS	0.00**	0.00	0.00***	0.00	0.00***	0.00
Time to survey	-0.01**	0.00	0.00	0.00	0.01**	0.00
Participant type	0.16	0.14	0.46*	0.22	-0.05	0.14
Read to	-0.28†	0.15	0.06	0.25	0.00	0.16
Age	0.00	0.00	0.00	0.00	0.00	0.00
Gender	-0.02	0.10	0.53**	0.17	-0.12	0.10
Education	-0.03	0.02	0.02*	0.03	0.02	0.02
Time of day	*included*		*included*		*included*	
Weekday	*included*		*included*		*included*	
N	649		674		679	
R^2	0.088		0.067		0.092	
Adj. R^2	0.062		0.041		0.067	
Residual Std. Error	1.660		4.456		1.762	
F Statistic (df)	3.591*** (17,631)		2.741*** (17,656)		3.944*** (17,661)	

Note. *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; † $p < 0.10$