

Face Time Versus Test Ordering: Is There a Trade-off?

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Background: As clinician-patient face time comes under pressure, clinicians might consider substituting testing for time spent in diagnostic reasoning, history, and physical exam.

Objectives: To explore the relationship between clinician-patient time and medical resource utilization.

Methods: In the Massachusetts General Hospital/Massachusetts General Physician Organization outpatient radio frequency identification project, clinicians and patients wore real-time location system (RTLS) tags. “Face time” was defined as the duration patients and clinicians were collocated. Radiology testing was used as a proxy for medical resource use. A radiology test was determined to be associated with a clinical encounter if it involved the same patient and clinician and occurred less than 3 months after the index encounter. Radiologic data were derived from the electronic health record and test appropriateness proxy score from the radiology order entry system. Data were synthesized and analyzed using standard structured query language and statistical analysis.

Results: From July 2008 to October 2010, 2086 clinical encounter medical records and RTLS-measured face times could be associated: 1957 for primary care (PC) and 129 for urgent care (UC). Of these, 471 met study criteria. In PC, shorter face time was associated with more testing, but shorter wait times and flow times. In UC, testing was not associated with shorter face times, but was associated with shorter wait times and longer flow times.

Conclusion: Our pilot suggests RTLS can capture face time and trade-offs between face time and testing. Ongoing studies will elucidate how these trade-offs affect patients, clinicians, and health-care systems.

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The time patients and clinicians spend together is usually when the most important clinical decision making occurs, is central to the clinician-patient relationship, and is at the core of clinical care.¹⁻¹⁶ Time, unfortunately, is not an infinite resource. In clinical scheduling, time is often allocated using schedule templates with blocks of time, such as 15/30 minutes or 20/40 minutes. In these limited intervals, the physician and patient must address a wide variety of concerns and complaints. This set of complaints and concerns (ie, the chief complaint, secondary, tertiary, and others) take time to address. Recent work suggests that within an encounter a clinician typically deals with one of these problems every 1 to 3 minutes.¹⁷ In this way, the clinical encounter might be considered a packing problem. A packing problem is a class of optimization problems where the object is to pack objects together as densely as possible¹⁸ (also often referred to as knapsack or pallet problems). In the case of the clinical encounter, a packing problem refers to how much useful activity (eg, addressing clinical complaints) a clinician and patient can “pack” into their limited time together.

If time is limited, how do clinicians respond? As encounter time shrinks, as it may do under volume-based incentive structures, the number of complaints that can be managed within the allocated time interval also decreases. However, clinicians do not disregard or drop complaints randomly. Rather, dealing with the chief complaint is usually preserved at the potential expense of postponing addressing other concerns perceived as less pressing.^{17,19,20} This strategy may be inadequate in the long run, in that problems deferred can ripen and return in a less manageable, more costly state.

There are a range of strategies one might pursue when dealing with diagnostic challenges as encounter time decreases. A common strategy used in many industries that deal with overtaxed resources is to try to use these resources more efficiently or off-load some of the demand to parallel resources. In the clinical setting, a way to off-load the demands of decision making and diagnostic reasoning may be to replace these time-intensive processes with testing or referrals, which may be done offline or asynchronously.

Measuring the face time, the part of the clinical encounter where the clinician and patient are actually together, is challenging in the clinical setting. Previous methods have ranged from surveys and administrative data to time-motion studies.

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Each method has had its own set of limitations.^{7,8,21-26} Surveys and administrative data are subject to recall bias and anchoring or averaging of values. The latter is a particular problem because it is clearly known that variance is at least as important as average behavior, if not more so, in driving system performance.²⁷ Time-motion studies are excellent at identifying specific measures in detail but are expensive and prone to distort subject behavior just by the presence of observers.

Real-time location systems (RTLs) are a relatively new method that can help solve this problem. Commonly used outside of healthcare, RTLs are a class of technologies used to identify and track the location of objects, typically in an indoor setting. Metaphorically they may be considered an indoor form of a global positioning system. As such, they hold similar potential to be used in a wide variety of ways and to serve as the infrastructure for yet-to-be-developed innovations beyond inventory and people tracking. These systems can be based on a wide variety of signaling modalities including radiofrequency (RF), infrared (IR), and ultrasound,²⁸ and use a variety of methods to resolve the location of an object or person in time and space. In active systems, the tags themselves emit a signal that is detected by an array of receivers. In passive systems, the antennae/receivers emit a signal in a mode such as RF, the tags reflect it, and the receiver detects it. All systems have varying degrees of granularity, signal resolution, noise, and latency with regard to location and time. To date, the most common use of RTLs both in and out of healthcare has been for inventory tracking.²⁹⁻³¹ Part of the purpose of the Massachusetts General Hospital/Massachusetts General Physician Organization (MGH/MGPO) outpatient radio frequency identification (RFID) project has been to determine the feasibility of adapting these systems for use in busy clinical settings and monitor clinic system behavior.^{32,33}

In this analysis we were able to use RFID to determine the trade-off between face time and diagnostic testing.

METHODS

As part of the MGH/MGPO outpatient RFID project, several primary care, urgent care, and specialty clinics had RFID-based RTLs installed. Clinicians and patients were asked to wear RTLs tags. Participation was voluntary. Flow data were derived from RTLs. Wait time was defined as the time from check-in/registration to the time the patient and clinician were colocated in the same exam room. Face time was defined as the length of time that patients and clinicians were colocated in the same room. Flow time was defined as

Take-Away Points

We can now successfully install real-time location systems (RTLs), run these systems in healthcare settings, and extract useful information from them. We can capture work flow behavior such as face time, wait time, flow time, and utilization, and link these data to other sources such as electronic medical records for deeper insight into how our healthcare delivery systems behave. In this study, we demonstrated that:

- We can measure face time, wait time, and flow time with RTLs.
- We can link clinical behavior (eg, face time) with resource utilization.
- We can distinguish different clinical behavior across clinical units.

the time from patient check-in/registration to patient check-out/deregistration. See **Figure 1**. This project was approved by the MGH institutional review board.

Radiology testing was used as a proxy for medical resource use. These tests are part of routine medical practice and are relatively easy to identify from the electronic health record (EHR). The inclusion criterion was any radiology test for an adult patient that could be associated with a specific clinical encounter. This condition was met if the radiology test shared the patient's unique identifier, if the ordering provider and face-time clinician were the same, and if it was the first radiology test to occur less than 3 months after the index encounter. Patient under 21 years old were excluded from the study. Test data were derived from the hospital research patient data registry and EHR.

Testing Appropriateness

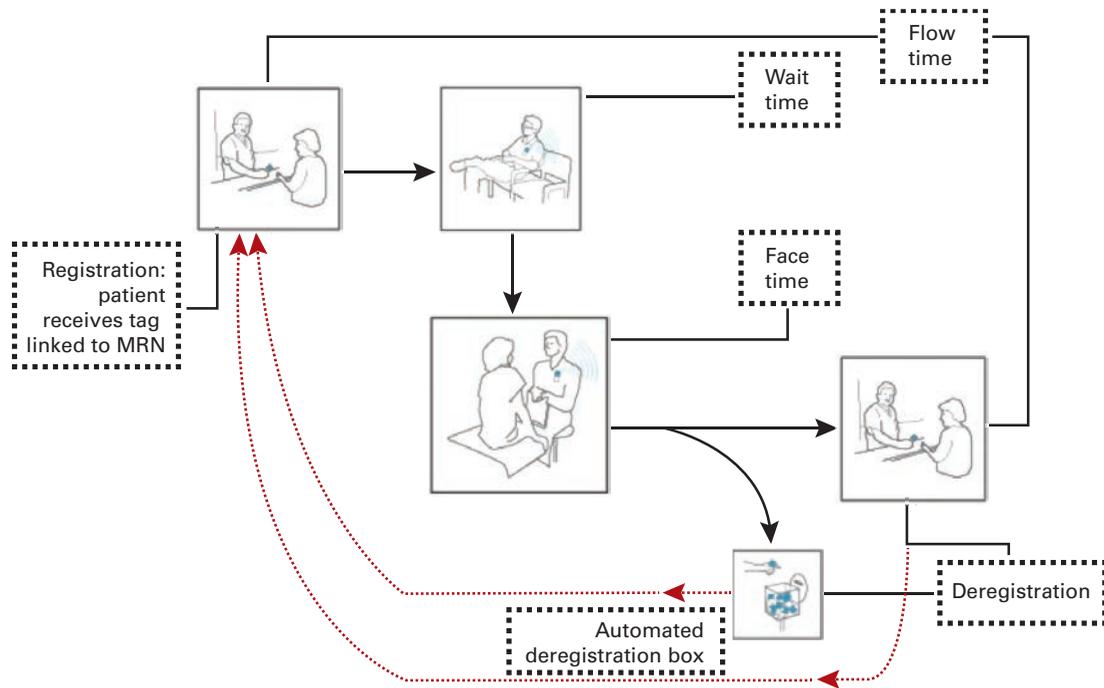
The appropriateness of the tests was estimated using the MGH radiology order entry (ROE) system.³⁴ Radiology tests ordered via ROE receive a score that is a proxy for level of appropriateness (range: 1-9, where 1 is completely unacceptable and 9 is completely acceptable). The score is generated online at the time of order entry and has to be acknowledged by the ordering clinician before the order goes through. The scores in our system tend to be skewed toward the high end, with a median value in our sample of 8. Tests with scores of 7 or more met the minimal level of appropriateness for this study. Clinicians can order radiology tests regardless of the score they receive.

Data were processed and stored in an encrypted secured database. Data were analyzed using JMP software (SAS Institute Inc, Cary, North Carolina) with standard statistical analytic methods.

RESULTS

From July 2008 to October 2010, 2086 clinical encounter medical records and measured face times could be associated. There were 1957 primary care visits and 129 urgent care visits (**Figure 2**). The median age of the patients was 45 years (range, 19-96 years); 35% were male and 65% were female.

■ **Figure 1.** Real-Time Location System Work Flow



MRN indicates medical record number.

Most (77%) patients were Caucasian, 7.8% were black, 7.3% were Hispanic, and 5.5% were Asian.

Testing

Out of 2086 encounters, 792 patients had associated radiology tests, 471 met study criteria, 368 had tests ordered through ROE, and 72 received ROE scores of 1 or higher. Scores ranged from 1 to 9. In primary care, 9% of visits resulted in radiology testing, whereas in urgent care 55% of encounters resulted in some form of radiology testing. Testing also occurred more frequently when encounters occurred in the first half of the calendar year ($P < .01$) and when tests were ordered in second half of the workday ($P = .1$).

Process Measures

Testing Appropriateness. A total of 72 encounters could be associated with the EHR, the RTLS database, and the ROE database, and had scores of 1 or greater. See the **Table** for time versus testing results. On the whole, face time was weakly correlated with ROE score. However, when stratified by the subgroups, primary care and urgent care providers behaved differently (**Figure 3**). As time increased for patients seeing urgent care providers, appropriateness increased. The opposite was true for the primary care group. In the primary care group, patients with the low-scoring tests (score ≤ 7) had both longer face time duration and more face time variance than patients

with higher-scoring tests. Patients with low-score tests had a mean face time duration of 6.5 minutes (standard deviation [SD], 9.2 minutes) versus a mean face time duration of 5.7 minutes (SD, 5.6 minutes) for patients with high-scoring tests ($P = .01$ for difference in variance). Of the low-scoring (≤ 7) tests in both groups (9 in primary care, 5 in urgent care), there were 7 magnetic resonance imaging (MRI) studies of the spine (5 lumbar, 2 thoracic), 1 MRI study of the brain, 1 MRI study of the knee, 1 magnetic resonance cholangiopancreatography, 2 computed tomography (CT) scans of the brain, 1 CT scan of the abdomen, and 1 x-ray for a foreign body in the eye.

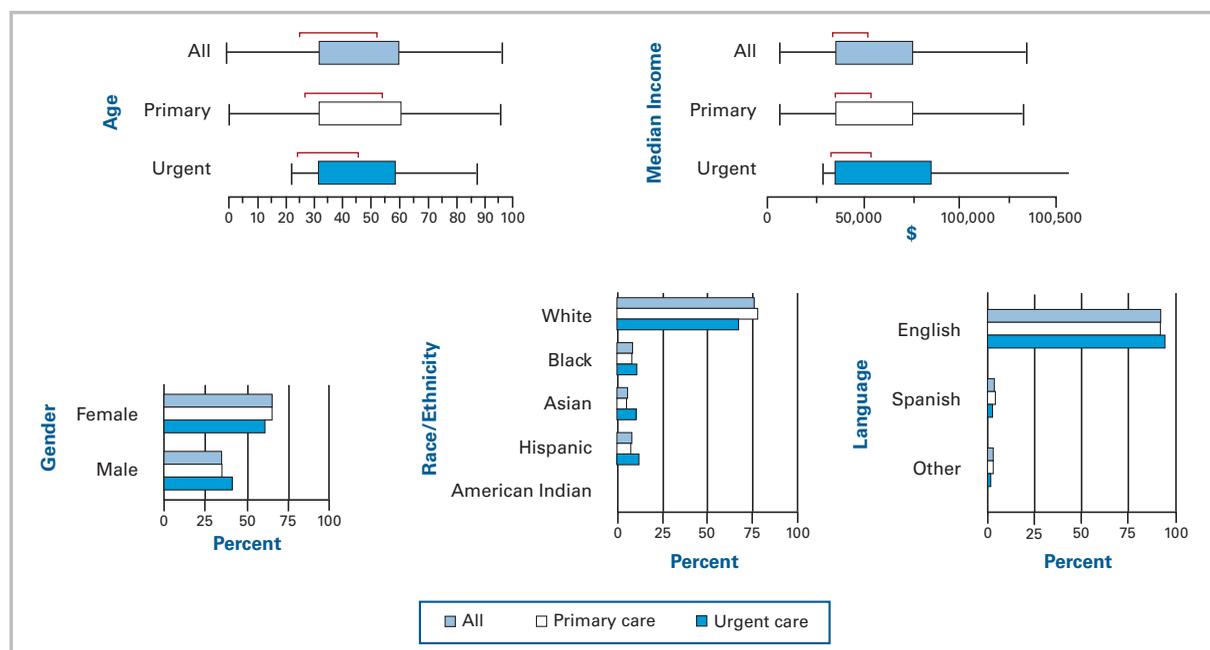
Limitations

During the course of the MGH/MGPO RFID outpatient project, there were several periods in the development and implementation process when medical record numbers were not collected due to clinic preference. This incomplete data capture (<100%) could have led to sampling bias. That substantial data were gathered across 5 separate clinics over several time periods should help allay this concern.

DISCUSSION

The idea of real-time location has been a recurring theme in popular culture for a long time. It has regularly appeared in science fiction and has long been a technology on the verge

■ **Figure 2. Patient Demographics**



of realization. Real-time location systems are technologies designed to let the end user answer the questions of what, where, and when: what it is you are looking for; where it is; and importantly, when it was last at that location (as close to real time as possible). That is in contrast to conventional inventory systems, which focus more on what and where with relatively little focus on temporal resolution, and on time-motion analysis methods, which tend to be very labor intensive and to have significant sampling issues.

Real-time location systems use a wide variety of physical modalities: RF (eg, Wi-Fi, ultra-wideband), IR, and ultrasound. These categories break down further into the functional modalities of passive, active, or hybrid, each with their own strengths and weaknesses.

Passive RFID RTLSs are perhaps the most widespread; they are used for inventory control in warehouses, in highway toll booths, and for monitoring people while running marathons. Passive RFID systems consist of 3 parts: a broadcasting antenna, a tag with an integrated circuit and antenna, and a receiver antenna. The antenna broadcasts, the tag reflects the RF signal back, and the receiver records the tag's signal. In active RFID systems, the tags are self-powered transponders whose RF signal is read by antenna/receivers. Infrared systems work similarly, though in the IR band. Ultrasound devices tend to act as active systems; that is, the tag is powered and emits the signal. The RF-based systems use a variety of algorithms to locate where the tag is, usually a form of triangulation. In hybrid systems, RF systems are usually combined with a directional modality

like IF or ultrasound, which act as tie breakers for ambiguous signals.

Real-time location systems were first used in the health-care setting as a form of sophisticated inventory management for expensive mobile assets such as infusion pumps, electrocardiography machines, and beds. This use allows just-in-time inventory management, which reduces staff searching, required on-site inventory, and equipment loss, and improves equipment maintenance schedules. For this type of use, the temporal and spatial demands are relatively low.

More recently, RTLSs have been moving into the role of operation measurement, analysis, and intervention. Here the temporal and spatial demands are significantly higher: required spatial/temporal resolutions are 1 to 2 m² per 10 seconds. That is necessary to track the movement of patients and staff who move rapidly and often interact briefly, unpredictably, and in close and constrained environments.

The clinical applications of RTLSs, however, are still at a relatively early stage. In our own work, we have used the technology to begin mapping how tightly coupled clinical systems behave; to determine the effect of providing feedback on wait time, face time, and flow time to clinicians; to link process measures derived from RTLSs such as face time to clinical and laboratory databases; to explore the effect of time on resource utilization and outcome; and to help measure hand hygiene compliance.

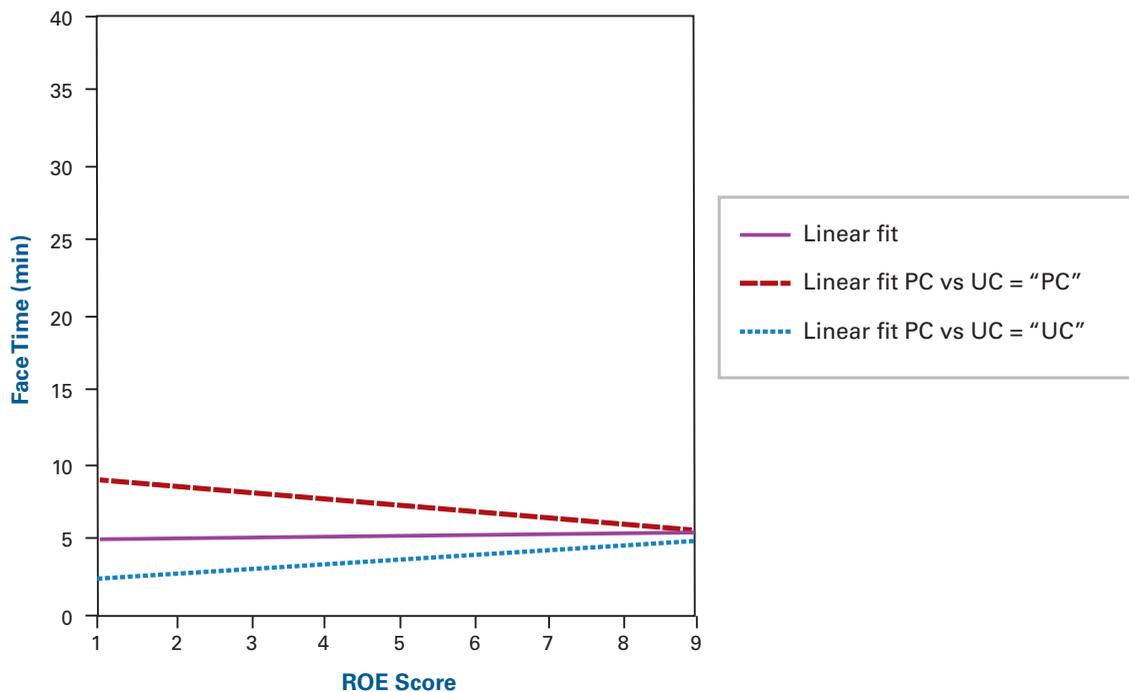
To implement these systems for clinical and managerial use, one must address several challenges. Technically, these systems

■ **Table.** Time Versus Testing

Type of Provider	Face Time, min, Mean			Flow Time, min, Mean ^a			Waiting Room Time, min, Mean		
	Radiology Test Ordered	No Radiology Test Ordered	P	Radiology Test Ordered	No Radiology Test Ordered	P	Radiology Test Ordered	No Radiology Test Ordered	P
Both primary and urgent care	10	14.9	<.0001	69.8	71.8	NS	14.3	10.1	.2
Primary care	10.1	15.1	<.0001	63.1	80.7	<.0001	9.6	13.1	<.05
Urgent care	9.9	9.8	NS	100.7	83.7	.05	5.3	9	NS

NS indicates not significant.
^aTime from check-in to checkout.

■ **Figure 3.** Face Time Versus Appropriateness of the Test Ordered^a



PC indicates primary care; ROE, radiology order entry; UC, urgent care.
^aScore (whole) = (duration of face time - 5.40)/0.06. Score (primary care) = (duration of face time - 9.72)/0.4.

often are not as good as our cultural expectations may demand and often have limitations with regard to temporal/spatial granularity, latency, and signal-to-noise ratio. The information generated can be complex to analyze, interpret, and present. These systems have their own inventory concerns surrounding tag supply and cost. In addition, cultural concerns surrounding privacy are often raised (ie, Big Brother is watching), even though much of the same and even more information is broadcast regularly by peoples' own mobile phones. It is important to remember that any technology change is a culture change.

The cost of installation will depend on a variety of factors including the extent and quality of existing information technology infrastructure, the density of the floor plan, the age and

construction of the buildings, and the cost of tags, receivers, and software. As a frame of reference, expect installation cost to be on the same order of magnitude as upgrading all the computers on a clinical unit.

The business model for RTLSs in healthcare is essentially one of cost savings, improved delivery of care, and reduced errors rather than revenue generation. The return on investment for RTLSs for mobile inventory management is clear in this regard. The argument for RTLSs in operations improvement is similar. Although the evidence is only now starting to come in, efficiencies gained and errors avoided should readily provide a positive return on investment. Finally, as these systems improve, they may enable automated time-based evalu-

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ation and management coding, augmenting or replacing the current documentation-heavy system (eg, required elements of history, physical exam) currently in place.

Hospitals have a great deal to gain from RTLs. For example, one of the challenges facing general hospitals is how to deliver care efficiently. Unlike manufacturing facilities where one can physically line up all the resources one needs to assemble a product, general hospitals are complex physical spaces where the needed resources can be located almost anywhere. Real-time location systems in principle provide the mechanism to set up virtual pathways to deliver care. If guidelines are about delivering the right therapy or test to the right person at the right time, RTLs are the logical facilitating technology. If privacy rules (eg, the Health Insurance Portability and Accountability Act) require that only those providers in the patient's clinical path have access to the patient's information, RTLs tags can provide the key. Finally, RTLs in one form or another will likely become the backbone of future sensing environments in hospitals linking EHRs, point-of-care testing, and other hospital resources to the patient and provider.

This study should be viewed in this context, specifically, as an early step toward understanding the role of this technology in the healthcare environment and as a new tool to help integrate the flood of information passing through our healthcare system. Ultimately, time, place, and duration shape how care is delivered. Therefore, the primary purpose of this study was first to determine whether it was possible to use RTLs to explore the relationship between the time shared by the patient and the clinician and the subsequent choices made about clinical resource utilization.

Our data appear to indicate that shorter face time is associated with higher likelihood of ordering a test, shorter wait times, and shorter flow times in the primary care setting. This, however, does not appear to be true in the urgent care setting, in which testing was not associated with shorter face time and was associated with both shorter wait times and longer flow times. On the whole, there was significantly less radiology testing per encounter in primary care than in urgent care. These behaviors may relate to the different demands found in the 2 types of settings. Primary care tends to be oriented more toward maintenance than discovery; with incentives to increase access, less time per patient can potentially translate into more patients seen per day and shorter wait times. In the urgent care setting, a diagnostic and/or management decision must be made within a limited time window, placing a premium on discovery and less emphasis on volume. Our study suggests that trade-offs between face time and testing occur and that there may be a cost with regard to appropriate use of resources. Our data using our proxy for test appropriateness, while relatively sparse, seem to suggest that in urgent care less patient-provider

time results in poorer use of testing resources, whereas in the primary care setting low-scoring tests were associated with increased variability in the time spent with the patient. This more variable time may indicate the presence of nonstandard cases. Nonstandard cases may potentially have more diagnostic ambiguity, which in turn one might hypothesize may drive more open-ended histories, physicals, and testing, or perhaps even a defensive medicine stance. Almost twice as many low-scoring tests occurred in the primary care group even though the proportion of encounters resulting in tests in this group was lower. The majority of these were imaging studies of the central nervous system.

This early work and others,^{32,33,35-38} where the technology was evaluated against other time-motion capture methods and was used in both the outpatient and operating room settings, support the ideas that RTLs can identify patterns in patient-clinician interaction with similar if not more precision and detail than prior techniques and that both time and context appear to influence the test-ordering decisions clinicians make. Studies now ongoing using RTLs with larger samples will determine whether this suggestion is valid and will allow further elucidation of the time/work trade-offs made by clinicians. As we learn more about how time influences resource use, we should be better able to determine whether or not these trade-offs are desirable for patients, clinicians, and the healthcare system as a whole and to design clinical delivery systems that optimally deliver continuity, access, and resources while preserving the essential time between clinicians and their patients.

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