European Journal of Radiology 109 (2018) 88–94

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Research article

The success of walk-in-computed tomography in practice

Jasper van Sambeek[a,*], Marjanne Luinstra[b], Els te Loo[b], Milan Pijl[b]

[a] University of Twente, Faculty of Behavioural, Management, and Social Sciences, Department of Industrial Engineering and Business Information Systems, Drienerlolaan 5, 7522 NB Enschede, The Netherlands
[b] Rijnstate Hospital, Department of Radiology and Nuclear Medicine, PO Box 9555, 6800 TA Arnhem, The Netherlands

ARTICLE INFO

Keywords:
Access time
Operations management
Process improvement
Access system
Patient preferences
Stakeholder approach

ABSTRACT

Background/objective: Long access time to computed tomography (CT) facilities is seen as a substantial problem in many hospitals. Walk-in is an intervention that eliminates access times, since it gives patients direct access without an appointment. The Rijnstate hospital implemented walk-in CT in 2010, which offered the opportunity to study the positive and negative effects of walk-in CT in practice and how these effects are balanced.
Material and methods: Employee interviews ($N = 10$), patient surveys ($N = 535$) and a data analysis using data from the Electronic Patient Record (EPR) of 129.148 patients between October 2008 and March 2017 were conducted.
Results: All stakeholders stated that the system improved with the introduction of walk-in. The interviews also resulted in main performance indicators: access time, waiting time, one-stop-shop, autonomy of choice, productivity and employee satisfaction. The patient survey divulged the maximum acceptable waiting time: 79% of patients stated this to be 15–30 minutes or more. When asked which performance indicator is most important, 'one stop shop' was mentioned by 134 patients over access time, waiting time and autonomy of choice (ranged from 79 to 88). The data analysis showed a doubling in production, while CT capacity hardly increased. The percentage of outpatients that had to wait 30 minutes or less has decreased from 85.2% in 2009 to 59.5% in 2016, but the absolute number of outpatients with these waiting times increased from 5.146 to 7.681. Overtime production regarding outpatients has decreased over the years.
Conclusions: Walk-in CT performs better regarding the main performance indicators than a full appointment system. The reasons are that it almost nullifies CT access time and enhances one-stop-shop for patients. Walk-in also improves satisfaction of patients, referring physicians as well as the entire radiology staff, technicians and doctors alike. Furthermore, all results suggest that productivity can be higher with walk-in than with only appointments.

1. Introduction

Wait times for health care is a major problem in many countries [1]. One of the main causes for these lengthy waits is access time, which is defined as the time a patient has to wait until his or her appointment [1,2]. A long access time is obviously inconvenient for patients, since this unnecessarily lengthens the care pathway and thereby postpones recovery. Long access times to radiology, which includes computed tomography (CT) facilities, are a considerable problem in many hospitals [3]. An important reason for this is that a large number of patients who require a CT scan either have or are suspected of having cancer, and it is becoming increasingly clear that being in a state of uncertainty has a negative impact on these patients' well-being [4–7]. In the Netherlands, for example, patients often have to wait weeks for the first appointment slot [8].

Many types of interventions have been implemented in radiology departments to improve access times [9]. The intervention that has resulted in the greatest improvement is to provide patients with direct access to the facilities without an appointment, thus eliminating access time. This is referred to as a walk-in system. However, many hospital managers and radiologists seem to view walk-in CT facilities as undesirable. Their main concern is that allowing patients to walk in would lead to unacceptable waiting times in the waiting room and lower productivity, caused by the unpredictable distribution of patient arrivals. These concerns are based on assumptions, though, and the advantages that these walk-in facilities could offer are promising.

* Corresponding author.
E-mail addresses: jvansambeek@sleutelnet.nl (J. van Sambeek), j.m.luinstra@student.utwente.nl (M. Luinstra), eteloo@rijnstate.nl (E. te Loo), MPijl@rijnstate.nl (M. Pijl).

https://doi.org/10.1016/j.ejrad.2018.09.031
Received 6 March 2018; Received in revised form 25 September 2018; Accepted 28 September 2018

In addition to eliminating access time, walk-in CT facilities offer patients 'one-stop shopping' and the ability to choose their own time of arrival. With one-stop shopping, a CT scan can be performed on the same day as other hospital visits, such as an outpatient consultation. This eliminates the need for an additional hospital visit when it becomes clear during the first consultation that a CT scan is necessary, and means that the patient can have the scan immediately. These advantages may be more important to patients than the anticipated disadvantage of longer waiting times in the waiting room. Modeling has shown that walk-in systems seem to provide considerable advantages in a number of other hospital departments [10–13], and several studies from the literature have confirmed that walk-in CT facilities are promising in theory [14–17]. However, we could find no evidence in the literature that was based on the implementation of walk-in CT facilities in practice.

The Dutch Rijnstate hospital has been working with walk-in CT facilities since 2010, and this offered us the opportunity to study its effects using real data and actual experience. Because the implementation of the walk-in CT facilities was completed some years back, it was possible to study the effects in a steady state in which all teething problems had already been dealt with. Our objective was to study the positive and negative effects of walk-in CT in practice and how these effects are balanced. Our main research question was the following: What are the positive and negative effects of Rijnstate's walk-in CT system for stakeholders, and is this walk-in system more appropriate than an appointment system?

2. Material and methods

Rijnstate is a large teaching hospital in the east of The Netherlands with 16 radiologists, 8 radiology residents, and 3 doctors of nuclear medicine. The hospital has three CT scanners at two locations. Until 2009, Rijnstate worked with an appointment system. In January 2010, they introduced a walk-in system for all outpatients and emergency patients. This is not a 100% walk-in system, however, because inpatients and outpatients who require special preparation (for example, kidney-preserving hydration therapy) are still given an appointment. Furthermore, cardiac studies, virtual colonoscopy, and biopsy procedures are planned and on specific patient's request it is possible to make a (future) appointment. All other patients (including those being scanned using an oral and/or intravenous contrast agent) have access to the walk-in system. The system meets Dutch and European quality requirements and patient safety standards.

A stakeholder approach was chosen for this study, because the change from an appointment to a walk-in system had an impact on many stakeholders, and having the trust of the relevant stakeholders is considered to be an important factor in hospitals [18]. The following stakeholders were considered: patients, referring physicians, hospital management, radiologists, X-ray technicians, and the front office employees (who do the planning and staff the reception desk). These stakeholders were selected based on their influence on or interest in the choice of CT access system. This study focused on assessing the walk-in concept for the CT modality by evaluating the application in practice.

To assess the effects of the walk-in CT system, we conducted interviews with employees, patient surveys, and a data analysis of electronic patient records (EPR). The approaches of the interviews, surveys, and data analysis are explained in the following sections. The researchers determined these approaches in cooperation with the lead radiologist and the radiology manager.

2.1. Interviews

Between November 22 and November 30, 2016, we interviewed 10 hospital employees who represented the employee stakeholders (2 referring physicians, 2 radiologists, 2 CT technicians, 2 front office employees, and 2 managers). Inclusion criteria were extensive experience with both walk-in and appointment CT systems. We interviewed both supporters and critics of the walk-in system. The focus of the interviews was on items of interest for the interviewee, relevant performance indicators, patients' reactions, personal and colleagues' perceptions, and lessons learned. We selected these topics based on what we found during our literature research on what is known about performance indicators and what is still unknown, so we could ask the appropriate questions. In this way, we aimed to include all the possible ways the walk-in system could have affected these stakeholders. The interviews were compiled into a report and summarized, and, together with the lead radiologist and radiology manager, conclusions were subsequently drawn.

2.2. Patient surveys

We used a questionnaire to study patient preferences. Inclusion criteria were that the patient had a CT scan in December 2016 or January 2017 and was present in the CT waiting room during office hours. There were 535 respondents, with an average age of 62 (standard deviation 13.9). The exact response rate is unknown, but during this period, all patients were asked to complete the questionnaire when they arrived at the reception desk and the majority of them returned it. We used descriptive statistics to analyze the results.

2.3. EPR data analysis

From the literature [19–21], we learned that EPR data analysis could be used to study the performance indicators of the various stakeholders (patients, employees, and hospital managers). The main topics for analysis were productivity and throughput times. Productivity was analyzed by comparing production rates and capacity over time, and throughput times were extracted from the patient journey, which was made possible by recorded snapshots of 'journey milestones' such as registration time and call-up time. Moreover, we could get a picture of the improvement potential by analyzing fluctuations in patient arrival times over the analyzed period of 8 years.

We collected the raw input data for the EPR data analysis from the EPR EZIS (Chipsoft, Amsterdam, The Netherlands). We processed this input data with Pentaho Kettle (Orlando, FL, USA) to make it usable for visualizations, which we generated in Tableau 10.1 (Seattle, WA, USA). Table 1 presents the variables we used. We selected these variables based on the potential to extract positive or negative performance indicators before and after the implementation of the walk-in system. The data used for the analysis included 129,148 patients seen and 143,068 scans performed between October 1, 2008 and March 31, 2017. We chose this period so we could analyze an extensive period before and after the introduction of the walk-in system. We conducted the data analysis by generating a variety of tables and diagrams in Tableau, which provided us with information about throughput times, productivity, and arrivals from various time periods. Several Rijnstate employees (including radiology management and radiologists) validated the output data.

Door-to-door time – time from registration at the department until report approval – differs between the appointment and walk-in system, since the moment of registration in the appointment system resembles the moment the patient arrives at the department for their appointment (excluding access time). In the walk-in system the moment of registration is equal to the first contact of a patient with the radiology department and includes waiting time. As a consequence, the door-to-door time within the appointment system is difficult to compare with the door to door time within the walk-in system, since the first, unfortunately, excludes the access time and the latter is the total patient throughput time. It was not possible to include the access time for the appointment system door-to-door time per patient. The reason is that the data from the system only makes possible analyzing access times retrospectively, by deducting the appointment date by the referral date.

Table 1
EPR data analysis variables.

Attribute	Description	Value
Data obtained		
Patient ID	Unique number for each referral, per patient	Integer
Scan ID	Unique number for each scan conducted	Integer
Patient type	Corresponding patient type	Emergency; Clinical; Outpatient
Specialty	Specialty of the referring physician	String
Description	Type of scan the patient underwent	String
Registration time	Time when patient registered at the radiology department desk	Date and time
Call-up time	Time when patient was asked to enter the CT room	Date and time
Departure time	Time when patient left the CT room and radiology department	Date and time
Wrap-up time	Time when radiologist approved the report	Date and time
Appointment time	Time of appointment, if present	Date and time
Location	Location of the hospital where the patient underwent the scan	Arnhem; Zevenaar
Scan protocol information	Extra information regarding the protocol that corresponds to the type of scan	With contrast; Without contrast
Variables calculated		
Waiting time	[Call-up time]–[Registration time]	Minutes
Scan time	[Departure time]–[Call-up time]	Minutes
Door-to-door time	[Wrap-up time]–[Registration time]	Minutes

But this method is not reliable, because a big fraction of appointments was not scheduled as soon as possible due to various reasons. Roughly, there can be added 3 weeks to the door-to-door time of the appointment system, because that was the average access time in 2009, before introducing the walk-in system.

3. Results

3.1. Interviews

A major topic in the interviews was what is important for the interviewee about the performance of the CT modality and which access policy suits this better. Hereby, we were able to extract various items of interests from the perspective of the different employee stakeholders in terms of the access policy. We translated these items of interest into a limited set of performance indicators that favor these specific items of interest. This made it clear that some indicators are of interest to a single stakeholder, and others to multiple stakeholders. Because the interview questions had no quantitative element, they did not show how the employees prioritized the performance indicators. Table 2 presents a summary of the results from the employee interviews on items of interest, performance indicators, and their scores for both systems.

All stakeholders indicated increased satisfaction since the introduction of the walk-in system, due largely to their contact with patients who expressed their satisfaction with this system. In addition, the employee interviews contained explanations for the increase in patient satisfaction (for example, a shorter period of uncertainty about the diagnosis and a minimum of hospital visits). The referring physicians stated that, thanks to the elimination of access time, the walk-in system made it possible to get a diagnosis more quickly so they could start treating their patients, outpatient departments needed fewer resources for follow-up planning, and there were fewer ‘second-best’ examinations (conventional radiology). They made possible the ‘one stop shop’ concept by reserving or creating places in their schedule for patients needing a CT scan and subsequent returning to the outpatient clinic. The radiologists mentioned that, for the walk-in system to be totally successful, the scan reports must be approved as soon as possible, which means they have to be more flexible. But they gave more weight to the advantages the walk-in system provides them with in terms of better service to their patients and to the referring physicians, and greater productivity. The process of reading and reporting of CT studies in the walk-in system has not changed when the walk-in system was introduced and is similar to that used in far majority in other Dutch

Table 2
Summary of interview results.

Stakeholders	Items of interest	Performance indicator	Favors appointment system	Favors walk-in system
All stakeholders[a]	Satisfied patients	All		+
Patients (according to staff)	Short period of uncertainty regarding diagnosis	Access time		+
	Short wait in waiting room (more acceptable in walk-in system)	Waiting time	+	
	Fewer hospital visits	One-stop shopping		+
	Have scan at moment of their choice	Autonomy of choice		+
Referring physicians	Quick diagnosis	Access time		+
	Follow-up phase easy to plan	Access time		+
	No second-best examinations	Access time		+
adiologists	Workload	Employee satisfaction	=	=
	Productivity	Productivity		+
	Approve report at moment of their choice	Employee satisfaction	+	
	Service provided to referring physicians	Employee satisfaction		+
X-ray technicians	Workload	Employee satisfaction	=	=
Front office (planning and reception desk)	Workload	Employee satisfaction	=	=
Hospital management	Service provided to patients	Access time, waiting time		+
	Productivity	Productivity		+
	Employee satisfaction	Employee satisfaction	=	=
	Fewer staff members required for scheduling	Productivity		+
	Competitive market advantage	Access time		+

[a] We present this item apart, because it is valid to all stakeholders and otherwise we would have to repeat it in every row of the table.

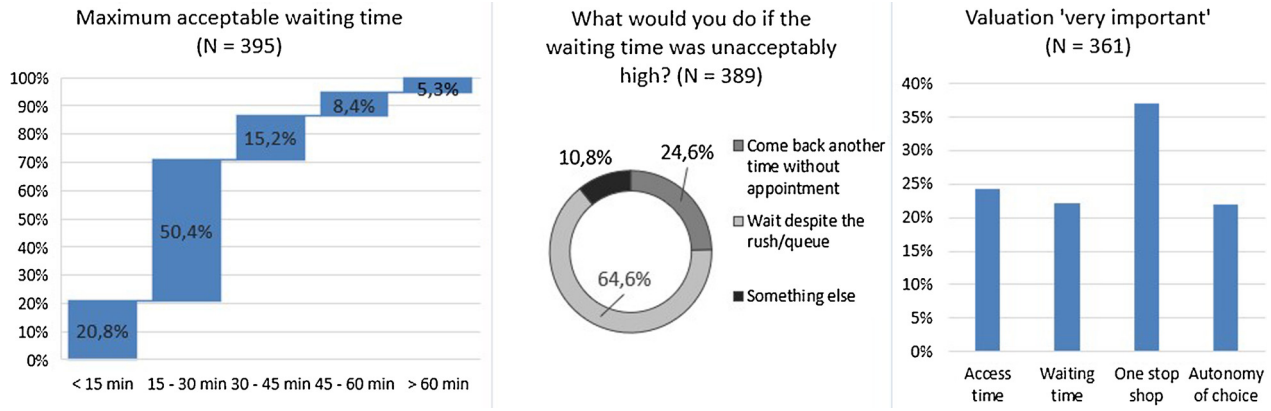

Fig. 1. Patient survey results.

hospitals. After the study was postprocessed by the technicians, radiologists read the study and reported it with the use of speech recognition followed by instant authorizing. The only difference with the old system was an increase in peak periods. Both front office employees and X-ray technicians said their workload is now greater during peak periods, but is roughly the same overall. The performance indicators for radiology management's items of interest favor a walk-in system.

3.2. Patient surveys

The three most relevant results from the patient surveys concerned maximum acceptable waiting time, their behavior if waiting time becomes unacceptably long and how they score the performance indicators. These results are presented visually in Fig. 1. Patient survey results.

Approximately 79% (100–20.8%) of patients indicated that a waiting time of a maximum of 15–30 minutes is acceptable. Around 21% wanted the waiting time to be less than 15 minutes. Approximately 29% (15.2% + 8.4% + 5.3%) of the patients found a waiting time of 30–45 min or more to be acceptable, and around 14% (8.4% + 5.3%) found even longer waits to be acceptable.

If patients found the waiting time to be unacceptably high, the majority indicated they would not leave the waiting room. This means they would choose to continue to wait, because the disadvantages of leaving are greater (such as having to come back for another hospital visit).

Of the patients who took part in the survey, 68.3% indicated their actual waiting time had been within the range they considered acceptable. One-stop shopping was chosen by 134 patients as the most important performance indicator in the CT facility's access policy. Short access time, waiting time in the waiting room, and autonomy of choice for the time of the scan all scored within a range of $N = 79–88$.

3.3. EPR data analysis

First we analyzed the productivity, defined as the number of scans executed within given capacity. An important factor that contributes to the productivity is the occupancy rate, defined as the number of minutes that patients have spent in the CT room divided by the total opening hours of the scanners times the number of scanners. So the indicator productivity is measured in number of scans and the indicator occupancy rate is a percentage. Besides occupancy rate, there can also be other factors that influence productivity, such as the speed of a scanner: the same scan takes longer in an old scanner than in a new scanner. In the last seven years, production in the CT department has shown a steady increase in both the total number of minutes spent in the CT room by all patients totalled (bars) and the total number of scans (line), as shown in Fig. 2.

Although both decreased slightly in 2012, comparing the results from 2009 with those from 2016 shows a significant difference in minutes spent in the CT room, which doubled from 451,584 in 2009 to 899,579 in 2016. The total number of scans also doubled, going from 11,279 in 2009 to 22,466 patients in 2016. This increase in production should be seen within the context of almost no increase in capacity. The number of scanners remained the same, and the only changes during these years were a slight increase in the number of CT technicians, and the installation of a faster scanner in 2015. This faster scanner is only a minor reason for improving productivity since the gain in scan time is minimal when compared to the entire patient handling. A faster scanner could cause more idle time – thus lower occupancy rate –, because extra setup times and limited demand. However, we saw an increase in the number of scan minutes instead of a decrease. Since the number of scan minutes doubled and the capacity hardly increased, there must be another cause of the increased occupancy rate and thus of the increased productivity. Since occupancy rate doubled and there have not been main changes next to the new scanner and the introduction of the walk-in system, it is probable that walk-in is the main cause of the increase of productivity.

In Table 3 we show the number and percentage of patients who waited fewer minutes than the number of minutes shown for the years 2009, 2012, and 2016. This overview is relevant because showing only average waiting times could imply that, when variability is high, the waiting time is much longer than shown for a substantial number of patients.

In Table 3 three types of patients are distinguished, since their access policy differs. Emergency patients are given priority, so their waiting time is obviously shorter. Inpatients have scheduled appointments, so their waiting time might also be shorter. So, the biggest challenge is to ensure acceptable waiting times for outpatients. The first column (≤ 0 min) means patients have no waiting time at all, and can go straight through when they arrive. In 2009, 98.5% of all emergency patients, 96.0% of all inpatients and 85.2% of all outpatients had to wait 30 minutes or less. In 2016, 99.1% of all emergency patients, 94.5% of all inpatients and 59.5% of all outpatients had to wait 30 minutes or less. The 30-minute limit is relevant because the patient surveys showed that the majority of patients indicated this limit is acceptable. Although the percentage of outpatients who waited less than half an hour decreased by more than 25% (from 85.2% to 59.5%), we found that the total number of outpatients who had their CT scan within half an hour increased by approximately 2,500 (from 5,146 to 7,681) in this period, which is an increase of almost 50%. This can be explained by the increase in production.

Table 4 presents the average waiting times for all patients during office hours. We see many time slots with relatively low waiting times, and some with high waiting times.

The average door-to-door time decreased considerably in the years

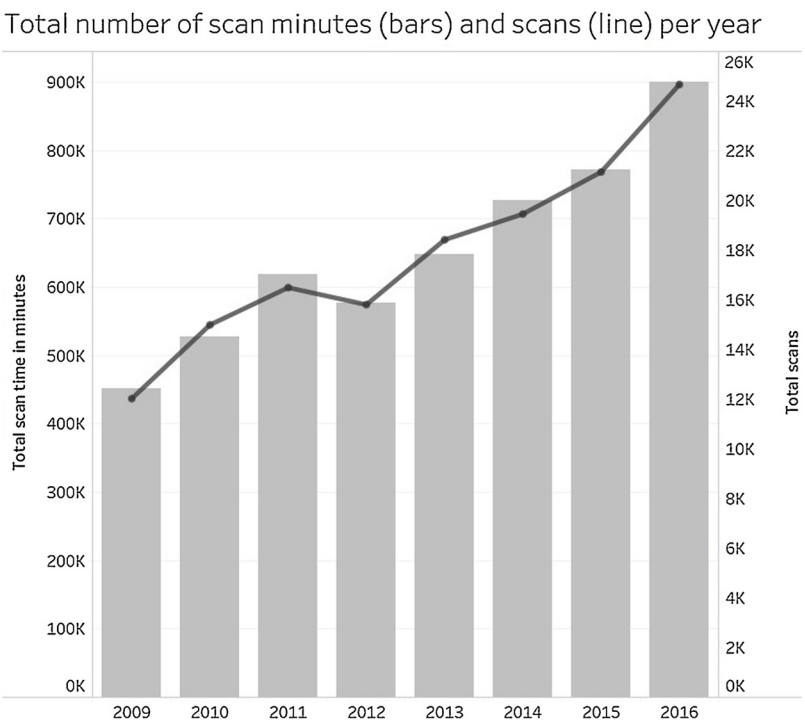

Fig. 2. Production data.

Table 3
Portions within given waiting times.

		≤0 min	≤15 min	≤30 min	≤60 min
Emergency	2009	92.50%	96.90%	98.54%	99.53%
		2,147	2,249	2,287	2,310
	2012	95.05%	97.80%	98.89%	99.66%
		3,073	3,162	3,197	3,222
	2016	93.97%	97.88%	99.13%	99.71%
		4,523	4,711	4,771	4,799
Inpatient	2009	59.53%	88.00%	95.95%	98.73%
		1,736	2,566	2,798	2,879
	2012	55.57%	87.43%	95.72%	99.06%
		1,596	2,511	2,749	2,845
	2016	44.28%	82.61%	94.54%	99.49%
		2,068	3,858	4,415	4,646
Outpatient	2009	28.81%	68.85%	85.21%	92.68%
		1,740	4,158	5,146	5,597
	2012	27.70%	62.38%	77.66%	90.16%
		2,212	4,981	6,201	7,199
	2016	14.69%	43.31%	59.47%	77.97%
		1,897	5,594	7,681	10,070
All patients	2009	49.87%	79.58%	90.73%	95.65%
		5,623	8,973	10,231	10,786
	2012	48.84%	75.61%	86.21%	94.15%
		6,881	10,654	12,147	13,266
	2016	37.90%	63.23%	75.31%	87.13%
		8,488	14,163	16,867	19,515

we studied. For example, the results of the average door-to-door time as observed in the third quartile dropped from 18.9 hours in 2009, to 8.1 hours in 2012, to 5.2 hours in 2016. As mentioned, for the appointment system in 2009 this is excluding the access time.

The combined results of the three data collection methods show that the walk-in system eliminates access time, and that this is highly valued by all stakeholders. Improvements in terms of higher productivity and more patient and employee satisfaction also point toward a walk-in system. All three methods show that, although waiting times in the waiting room can be longer in a walk-in system during peak periods, the overall waiting times appear to be acceptable if production does not increase much further without increasing capacity.

4. Discussion

We conclude that a walk-in CT system (with a limited number of appointments for certain types of examinations, for instance needing sedation, general anesthesia or collaboration with other departments such as ICU) functions better than one that is entirely appointment-based, primarily because it virtually eliminates CT access time, enhances the one-stop shopping policy for patients, and increases satisfaction among patients and referring physicians, as well among the radiology staff, technicians and doctors alike. Furthermore, all of the results suggest that productivity can be greater in a walk-in system than in one that is entirely appointment-based. Management should closely monitor waiting time, productivity, and production versus capacity, and make adjustments when necessary.

Literature indicates that reducing access times to diagnostic facilities positively contributes to patients' wellbeing, for example cancer patients can benefit from quick diagnosis [5,22,23]. Financial issues of the walk-in system were discussed with the hospital's board before introduction, but within the Dutch healthcare system these issues were not considered an issue big enough to withheld our patients this service. We deliberately did not opt for extending radiology department services out of working hours, because this would lead to a substantial increase of labor costs. Demand for maintenance and spare parts did obviously increase per year due to higher production, irrespective of the system when production increases.

In our study, we encountered only one substantial disadvantage of walk-in CT facilities, which was longer waiting times in the waiting room during specific periods. In our survey, 79% of patients indicated that a waiting time of up to 30 minutes was acceptable, and in 2016, 75% of patients had their examination start within 30 minutes. If patients had to wait longer than 'acceptable', most patients stated that they still choose to wait and therefore we conclude they preferred this waiting time above the disadvantages of the appointment based system. This could partly be explained by the fact that waiting in a walk-in system is considered to be less annoying than if patients expect to have their scan at a specific appointment time [15,24,25], and so patients at Rijnstate are willing to wait longer in the waiting room.

Table 4
Average waiting times per weekday.

		07:00–07:59	08:00–08:59	09:00–09:59	10:00–10:59	11:00–11:59	12:00–12:59	13:00–13:59	14:00–14:59	15:00–15:59	16:00–16:59	17:00–17:59
2009 access time = 4 weeks	Monday	9.7	12.1	19.2	22.3	17.1	13.8	16.2	20.1	18.1	10.0	1.5
	Tuesday	9.3	12.6	21.8	21.8	15.6	10.5	13.9	17.5	18.3	9.4	3.6
	Wednesday	7.8	10.3	15.2	20.1	14.9	12.1	12.9	16.5	16.4	6.4	9.1
	Thursday	5.6	9.6	19.9	19.9	14.5	14.3	15.0	16.8	14.8	11.5	1.8
	Friday	9.6	11.4	16.1	19.1	14.8	12.8	13.5	13.8	14.1	12.5	6.0
2012 access time = 0	Monday	6.3	9.3	12.7	19.4	20.0	27.2	22.4	18.5	17.1	10.8	0.3
	Tuesday	8.4	7.6	12.4	20.9	22.4	23.9	18.0	17.2	12.4	9.8	2.2
	Wednesday	4.7	8.3	12.5	18.8	18.3	21.6	15.9	15.0	16.4	8.7	1.9
	Thursday	1.0	8.2	13.0	21.3	22.7	27.6	21.1	18.7	15.0	7.8	4.4
	Friday	4.1	8.5	10.5	22.9	20.3	23.3	20.7	18.2	19.8	10.2	2.9
2016 access time = 0	Monday	4.2	12.4	22.1	30.3	30.7	39.5	37.2	26.7	29.5	24.6	3.1
	Tuesday	2.7	10.0	20.9	25.3	29.8	34.4	28.1	24.5	28.1	21.4	4.7
	Wednesday	5.0	11.9	21.1	31.2	30.7	32.5	29.4	24.1	25.2	21.3	2.7
	Thursday	6.1	10.3	20.9	30.4	32.3	41.5	30.1	25.9	27.4	21.3	5.2
	Friday	5.8	12.1	18.8	31.6	34.1	37.5	30.9	28.1	28.4	14.6	4.2

Walk-in CT is particularly advantageous if the door-to-door time is minimal and predictable, so that the referring departments can plan the patient's next visit when ordering the CT. This means the CT technicians need to handle the post-processing quickly, and the radiologist needs to read the study, write and approve a report quickly. This is often possible before the end of the day of the scan, and sometimes the day after, which decreases the duration of the diagnostic process, and subsequently the amount of time the patient has to wait for the examination results. When patients would like to use the one-stop shopping option, the radiologist can give these specific patients priority to guarantee that they receive their authorization on time. This makes it possible to start treatment earlier and might also be less costly, at least for the patient (fewer travel costs, peer support). A limitation of this study is that after the radiology management introduced a walk-in system to the CT facilities, they also implemented other improvements, so the increase in productivity cannot be attributed solely to the walk-in system.

Ideally, we had compared the productivity before walk-in and after. Unfortunately, this was not well comparable, because not only the access system changed but also the speed of a scanner and the number of CT technicians in peak hours. In other words, the capacity changed but the exact change over time is not possible to determine because it is built by several variables. We know the capacity increased only a fraction, because the number of scanners and opening hours are the main building blocks for the capacity. Therefore, the opinion of the involved employees that walk-in made possible the doubling of the production for the bigger part, can be reasoned.

We expect that our conclusions will also apply to CT facilities in other hospitals. Ideally, we performed our study in more than one hospital, but this was not possible since Rijnstate was the only hospital we knew of with years of experience with walk-in. With regard to equipment, the only condition is that there should be more than one scanner. If there is only one scanner, and this scanner fails, this will result in an unacceptable situation. Transitioning from an appointment to a walk-in system forms a major hurdle. Commitment to the walk-in CT facilities should be hospital-wide, meaning that all radiologists and referring physicians have to cooperate so that the change can be implemented all at once. Moreover, the introduction of a walk-in system requires radiologists and other staff members to be adaptable and flexible. This calls for careful preparation that involves all stakeholders, and after its introduction there will need to be a period devoted to fine-tuning the system. Communication is key in this process, because it will feel unnatural to most radiology staff members, and will also drastically change the way they work. Especially in the early years after introduction we performed several surveys – they all showed a decrease in access time and an improvement of satisfaction of patients, the radiology department and clinicians.

To make use of the walk-in CT facilities, patients have to meet certain preconditions, which are the absence of contrast-induced nephropathy conditions (determined beforehand) and the absence of dietary restrictions prior to their CT examination. The transition to a walk-in system must be accompanied by measures that ease this transition, such as expectation management, providing information to patients on current waiting times, influencing patient arrival times, encouraging staff to be more flexible, and selecting ‘smart’ appointment times. Another important measure is to have a separate preparation room for placing IV access lines. Very important is that radiology department employees believe in priority of patient safety, better care and satisfaction is the cause essential.

Studies in the literature were usually restricted to the introduction of an operations management (OM) solution, possibly with a calculation of the consequences [26]. We verified the effectiveness of walk-in CT facilities in practice. Our study offers a process intervention that can be implemented by all hospitals with more than one CT scanner. This intervention greatly increases the modalities’ performance, not only from the perspective of patients, but also from the perspective of all staff members and the hospital. This study provides sufficient evidence

that walk-in CT facilities work in practice. We suggest further research to determine to what extent our conclusions are valid in other hospitals. In addition, it would be valuable to study the suitability of walk-in systems in other radiology modalities and in other hospital departments.

Conflict of interest

The authors declare no conflict of interest.

References

[1] S. Luigi, B. Michael, M. Valerie, OECD Health Policy Studies Waiting Time Policies in the Health Sector What Works? OECD Publishing, 2013.

[2] L. Siciliani, J. Hurst, Tackling excessive waiting times for elective surgery: a comparative analysis of policies in 12 OECD countries, Health Policy 72 (2) (2005) 201–215.

[3] A.Z. Kielar, R.H. El-Maraghi, M.E. Schweitzer, Improving equitable access to imaging under universal-access medicine: the Ontario wait time information program and its impact on hospital policy and process, J. Am. Coll. Radiol. 7 (8) (2010) 73–81.

[4] C.M. Mulcahy, D.C. Parry, T.D. Glover, The “patient patient”: the trauma of waiting and the power of resistance for people living with cancer, Qual. Health Res. 20 (8) (2010) 1062–1075.

[5] C. Paul, M. Carey, A. Anderson, et al., Cancer patients’ concerns regarding access to cancer care: perceived impact of waiting times along the diagnosis and treatment journey, Eur. J. Cancer Care 21 (3) (2012) 321–329.

[6] N. O’Rourke, R. Edwards, Lung cancer treatment waiting times and tumour growth, Clin. Oncol. 12 (3) (2000) 141–144.

[7] L. Yu, R. Chojniak, M. Borba, D. Girao, M. Lourenço, Prevalence of anxiety in patients awaiting diagnostic procedures in an oncology center in Brazil, Psycho-Oncology 20 (11) (2011) 1242–1245.

[8] Wachttijden ziekenhuiszorg radiologie maart 2017, (2017) https://www.volksgezondheidenzorg.info/onderwerp/ziekenhuiszorg/regionaal-internationaal/wachttijden (accessed 28.04.17).

[9] B. Olisemeke, Y. Chen, K. Hemming, A. Girling, The effectiveness of service delivery initiatives at improving patients’ waiting times in clinical radiology departments: a systematic review, J. Digital Imaging 27 (6) (2014) 751–778.

[10] N. Kortbeek, M.E. Zonderland, A. Braaksma, et al., Designing cyclic appointment schedules for outpatient clinics with scheduled and unscheduled patient arrivals, Perform. Evaluation 80 (2014) 5–26.

[11] Y. Peng, X. Qu, J. Shi, A hybrid simulation and genetic algorithm approach to determine the optimal scheduling templates for open access clinics admitting walk-in patients, Comput. Ind. Eng. 72 (2014) 282–296.

[12] C. Yan, J. Tang, B. Jiang, Sequential appointment scheduling considering walk-in patients, Math. Probl. Eng. (2014) 2014.

[13] M. den Boer, Is het wachten zonder een afspraak de moeite waard? Master's thesis, (2009) Retrieved from https://thesis.eur.nl/pub/8417.

[14] N. Kortbeek, Quality-driven efficiency in healthcare. Doctoral dissertation, (2012) Retrieved from https://research.utwente.nl/en/publications/quality-driven-efficiency-in-healthcare.

[15] M. Scholtens, Visiting the CT-scan; appointment system or walk in? Patient preferences and possible arrival pattern. Master's thesis, (2009) Retrieved from https://essay.utwente.nl/60608/1/MA_thesis_M_Scholtens.pdf.

[16] J. Veldwijk, Do Today's Work Today: Don’t Send Patients Away!: an appointment scheduling algorithm that can deal with walk-in. Master's thesis, (2012) Retrieved from https://essay.utwente.nl/64509/1/Thesis%20Joost%20Veldwijks.pdf.

[17] M. Maraha, Efficiënter gebruik van CT-scanners: casus bij Medisch Spectrum Twente. Master's thesis, (2011) Retrieved from https://essay.utwente.nl/61467/1/MSc_M_Maraha.pdf.

[18] T.R.F. Postema, The role of intra-organisational stakeholder dynamics in IT-based innovation adoption processes in hospitals: Universiteit Twente. Doctoral dissertation, (2012) Retrieved from https://research.utwente.nl/en/publications/the-role-of-intra-organisational-stakeholder-dynamics-in-it-based.

[19] P. Yoon, I. Steiner, G. Reinhardt, Analysis of factors influencing length of stay in the emergency department, Can. J. Emerg. Med. 5 (3) (2003) 155–161.

[20] I. Chau, M.T. Kelleher, D. Cunningham, et al., Rapid access multidisciplinary lymph node diagnostic clinic: analysis of 550 patients, Br. J. Cancer 88 (3) (2003) 354–361.

[21] A. Nitrosi, G. Borasi, F. Nicoli, et al., A filmless radiology department in a full digital regional hospital: quantitative evaluation of the increased quality and efficiency, J. Digital Imaging 20 (2) (2007) 140–148.

[22] Y.L. Basta, K.M. Tytgat, J.H. Klinkenbijl, P. Fockens, E.M. Smets, Waiting time at a fast-track diagnostic clinic, Int. J. Health Care Qual. Assur. 29 (5) (2016) 523–535.

[23] R.D. Neal, P. Tharmanathan, B. France, et al., Is increased time to diagnosis and treatment in symptomatic cancer associated with poorer outcomes? Systematic review, Br. J. Cancer 112 (Suppl. 1) (2015) S92–S107.

[24] D.H. Maister, The Psychology of Waiting Lines, Harvard Business School, Boston, MA, 1984.

[25] G. Van den Heuvel, E. te Loo, Werken zonder wachtlijst – CT op inloop, Gamma Professional 60 (4) (2010) 26–29.

[26] S. Brailsford, J. Vissers, OR in healthcare: a European perspective, Eur. J. Oper. Res. 212 (2) (2011) 223–234.