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Abstract. Healthcare providers are under pressure to work more efficiently and in a more patient-focused way. One possible way to achieve this is to launch Business Process Redesign (BPR) initiatives, which focus on changing the structure of the involved processes and using IT as an enabler for such changes. In this paper, we argue that a list of historically successful improvement tactics, the *BPR best practices*, are a highly suitable ingredient for such efforts in the healthcare domain. Our assessment is based on the analysis of 14 case studies. The insights obtained by the analysis also led to an extension of the original set of best practices.

Keywords: Healthcare, Business Process Redesign, best practices.

1 Introduction

Healthcare providers need to reduce operational costs while improving the quality of care [9]. Since in various countries the healthcare sector is reorganized on a free-market basis, it makes sense for patients to visit the provider with the shortest access time or the lowest costs. The healthcare domain is responding to this trend with a focus on efficiency and process improvement. One dominant form of improvement initiatives that results from these developments is known as Business Process Redesign (BPR). In a BPR initiative, the focus is on the improvement of an entire, cross-functional business process. Typically, such an effort consists of describing the *as-is* situation, performing an analysis of the *as-is* to find bottlenecks, and constructing the *to-be* process [7].

In the BPR field, the use of so-called BPR best practices [16] is one way to support the creation of one or more *to-be* processes from the *as-is* process. A BPR best practice – or best practice, for short – is a solution that has been applied previously and seems worthwhile to replicate in another situation or setting. By going through this set of best practices, practitioners can find inspiration to generate evolutionary, local updates to an existing process. The use of a set of best practices can be easily integrated in existing redesign methodologies, such as the one in [18]. Furthermore, an evolutionary approach using best practices is probably the most appropriate for improvement efforts in the healthcare domain [3]. When applying best practices in the healthcare domain, the focus is on the

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organization and structure of the involved processes and not on improving the medical practice itself. In this sense, a best practice describes a pattern for improvement. In [14], a pattern-based analysis is applied on clinical guideline modeling languages to evaluate their support of the control-flow patterns.

While one earlier application of the best practices in the healthcare domain has been reported in [10], no convincing argument has been made yet about the potential of their application. Clearly, this is an important issue if successful and appropriate usage of best practices could help to move the healthcare domain to higher levels of performance. Against this background, we aim to further investigate the use of best practices in the healthcare domain by addressing the following questions:

1. To what extent are the best practices suitable for redesigning healthcare processes?
2. Is the use of best practices effective in the healthcare domain?
3. Is it possible to extend the set of best practices with the lessons learned from redesigning healthcare processes?

The outline of this paper is as follows. In Section 2, we provide some background information on the best practices and their application. Section 3 presents the methodology that has been followed in this paper to answer the research questions. In Section 4, we address the first research question, i.e., the suitability of the best practices to the healthcare domain. Section 5 deals with the second research question and in Section 6 the third research question is addressed. This paper concludes with a discussion and concluding remarks.

2 Background

In this section we present the best practices, which are embedded in a conceptual framework, and we provide a method for the application of best practices.

Although many methodologies, techniques and tools are available to facilitate a BPR effort, little concrete support is provided on how to create the *to-be* situation from the *as-is* [15]. For the guidance and support of the redesign process itself, we earlier defined a BPR framework [16] (see Figure 1). The various components of the framework help to distinguish the different aspects that can be addressed in a BPR initiative. These aspects guide users to the most appropriate subset of best practices that are relevant to improve a certain aspect. In [16], we have identified best practices related to the topics in the framework by conducting a literature review and evaluating the successful execution of BPR implementations. For each best practice, a qualitative description, its potential effects, and possible drawbacks are given. The identified best practices are considered to be applicable across a wide range of domains, such as governmental, industrial, and financial processes. For an overview of the 29 best practices we refer the reader to Appendix A. The framework and its associated best practices have been validated among a wide group of BPR practitioners in the UK and the Netherlands. The main conclusion is that the framework is helpful in supporting

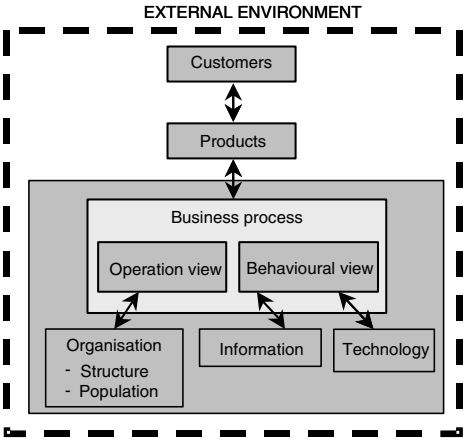

Fig. 1. The BPR framework

process redesign and that its core elements are recognized and frequently put to practice by the BPR practitioner community [13].

To provide methodological support for the application of the best practices, we described in [10] a sequence of successive phases that a BPR initiative may go through:

1. The process is *modeled* in such a way that it is a realistic image of the real process and that it can be used for *simulation* purposes. The process model and the simulation results for this initial model have to be *validated* with the process owner.
2. For each *best practice* it is considered which part(s) of the process, i.e., set of tasks, may potentially benefit from this particular best practice. The result of this step is (a) a list of applicable best practices, and (b) a list of process parts that may be changed by one or more best practices.
3. For each process part, the redesign consultant and the process owner decide which (combination of) best practice(s) is interesting. This step results in a number of *to-be* scenarios.
4. For each scenario a *new process model is created* by adapting the initial model. A simulation study is used to evaluate the effect of a scenario and the simulation results are compared with the results of the initial model. The models and results are validated with the process owner.
5. The final step is to *decide* which scenarios are taken into account when actually redesigning the process.

3 Methodology

To investigate the suitability and effectiveness of best practices for the redesign of healthcare processes, we mainly build on a set of case studies to address our

research questions. The case studies were found through a literature review and augmented with our own experiences in concrete BPR projects in the healthcare domain. To identify the appropriate case studies, we searched the ABI/Inform and INSPEC catalogues with search terms consisting of three parts (x and y and z). The first part of the search term, x, was related to the setting: health or care or healthcare or hospital(s). The second part of the search term, y, was related to the redesign element: design or redesign or reengineering or management. The third part of the search term, z, was related to the business process element: process(es) or pathway(s) or flow(s) of chain(s) or operation(s) or operational. This search led to the initial identification of 10 appropriate case studies. All the related articles describe the redesign of a healthcare process that involves the close participation of patients and state concrete redesign options and quantitative redesign results. One of the 10 articles we found describes a case study that has been carried out by ourselves [10]. We decided to add two more case studies on BPR projects that we recently undertook in the health care domain, and decided to include two more case studies that we were aware of through our cooperation with the Dutch Academic Medical Center (AMC). The latter two have been carried out and described by Elkhuizen [6]. In total, this brings the number of case studies that were considered for this paper to a total of 14.

4 Suitability of Best Practices

As stated before, the described redesign approach with best practices has been tested earlier within the context of a single case study [10]. This leads to the preliminary insight that some of the best practices seem applicable, but we wish to confirm that a large part of the best practices is applicable to a wide range of healthcare settings. In particular, we explore in this section the following question "To what extent are the best practices suitable for redesigning healthcare processes?". To answer this question, we make a distinction between the case studies that explicitly applied the best practices, and the case studies in which the participants did not use our particular set of best practices to create *to-be* scenarios.

4.1 Explicit Use of Best Practices

We have conducted three BPR initiatives in a healthcare setting that explicitly reflect on and use the set of best practices. In Table 1, these are listed as case studies 1 to 3. Each case study includes 5 to 7 feasible *to-be* scenarios and each scenario involves the combined application of multiple best practices. These best practices are also listed in Table 1 (see Appendix A for the meaning of the abbreviations). Case study 1 involved the improvement of the intake procedure that processes new requests for non-urgent treatment of elderly patients at a Dutch mental healthcare institute. One identified *to-be* scenario consists of asking the referring family doctor at referral for the medical file of the patient. This scenario combines the following best practices: *contact reduction* (REDUC), *exception* (EXCEP), *resequencing* (RESEQ) and *triage* (TRI). Another identified

to-be scenario consists of giving the intakers the full responsibility for the determination of the treatment plan. This empowerment of the intakers is prescribed by the *empower* (EMP) best practice. Case study 2 and 3 are performed at a Dutch hospital in the southern part of the Netherlands. Case study 2 evaluates the procedure for processing elective and semi-urgent Percutaneous Coronary Intervention (PCI) requests at the cardiology department. Examples of *to-be* scenarios that the process owner classified as successful are the use of an electronic registration form to add information at once to the central information system (a combination of ELIM, RESEQ, AUTO, SPLIT and TECH), and combining two intake meetings (COMPOS and REDUC). Case study 3 investigates the treatment processes at the dermatology oncology department including consultations, pre treatment care, treatment and post treatment care. Examples of proposed *to-be* scenarios are the immediate analysis of a biopsy while the patient is waiting (a combination of PAR, REDUC and ELIM) and combining the scheduling and informing of the patient (REDUC and ASSIGN). For case studies 1, 2 and 3 it can be concluded that for each study a substantial number of best practices is applicable.

Table 1. Case studies and applicable BPR best practices

Nr.	Subject	Applied best practices
		Explicit use of best practices
1	patient intake in mental healthcare institute [10]	COMPOS, TECH, CASEB, XRES, REDUC,EXCEP, RESEQ, TRI, AUTO, ELIM, INTG, PAR, EMP
2	invasive cardiologic therapeutic procedure in cardiology department	ELIM, RESEQ, AUTO, SPLIT, TECH, RELOC, CASEB, COMPOS, REDUC, XRES, SPEC
3	treatment process in dermatology oncology outpatient clinic	ASSIGN, INTG, PAR, REDUC, ELIM, RELOC, SPLIT, SPEC
		Implicit use of best practices
4	diagnosis process in outpatient gynecological oncology department [6]	TRUST, RESEQ, REDUC, XRES, TYPE, EMP
5	diagnosis in pulmonology outpatient clinic [6]	REDUC, RESEQ, TYPE, EXCEP, EMP
6	process at Walk-in Centre (multi-service facility) [1]	TRI, SPEC, ADD, XRES
7	operation cycle for emergency and hospitalized patients [2]	SPEC, CENTR, TRI, XRES
8	process at Magnetic Resonance Imaging (MRI) department [5]	TYPE, CASEB, ELIM
9	the outpatient consultation process in internal medicine department [11]	RELOC, REDUC, COMPOS, TECH, PAR, RESEQ, XRES, AUTO
10-14	other healthcare case studies	XRES

4.2 Implicit Use of Best Practices

The majority of the 14 case studies did not rely on an explicit consideration of our set of best practices to create *to-be* scenarios. In Table 1, these case studies are listed as case studies 4 to 14. However, because the related papers specifically describe the interventions that have been proposed, it is possible to determine retrospectively which of the best practices that we distinguished were used after all. We will refer to these as 'implicitly used' best practices. We conclude that a best practice is implicitly applied if part of the intervention is highly similar to the description of a best practice as published in [16]. In case study 4, for instance, part of the intervention consists of redesigning the diagnostic process such that a uniform set of examinations is provided for patients with dyspnea. A receptionist triages new patients to see whether they are referred for dyspnea. In this description we recognize, among others, the implicit use of the *case types* (TYPE) best practice and the *trusted party* (TRUST) best practice. The *case types* best practice "distinguishes separate processes and case types" which has been done for patients with dyspnea. The *trusted party* best practice suggests to "replace a decision task by the decision of an external party", i.e., trust the referral with dyspnea. Another example can be found in case study 7, which describes the redesign of an operating theater by changing the degree of specialization / generalization of the involved resources. Here, we derive the implicit use of the *specialist-generalist* (SPEC) best practice which is "consider making resources more specialized or generalized". Table 1 lists the best practices that we consider to be implicitly applied in case studies 4 to 14. Note that the number of best practices per case study is less than the number in the case studies we performed ourselves. The main reason for this is that in the papers that relate to case studies 4 to 14 only the implemented *to-be* scenario is described, while our case studies have included several possible *to-be* scenarios.

Based on this analysis, the answer to the question "To what extent are the best practices suitable for redesigning healthcare processes?" is that almost three quarters of the total number of available best practices has been applied, across a wide variety of healthcare settings. In the case studies that explicitly applied best practices, 17 different best practices have been used. In the case studies that implicitly used best practices, we distinguished 18 different best practices. Altogether, Table 1 covers 21 best practices out of the available 29. This indicates that our small test sample suggests that the existing set of best practices is suitable for application in healthcare. This does not necessarily mean that its application leads to improved performance. In the next section, we address the second research question and discuss the effectiveness of the application of best practices.

5 Effectiveness of Best Practices

In the previous section, our findings suggested that our best practices are applied in the healthcare domain. The next question, then, is "Is the use of best practices effective?". We consider the use of best practices to be effective, if the

to-be process created with the best practices shows an improved performance on the chosen performance indicators, i.e., the improvement goals of the redesign effort have been achieved. First, we evaluate the effectiveness of the best practices applied in case studies 1 to 3. In these case studies simulation studies are used to predict whether a *to-be* scenario may be effective. However, a simulation study cannot give the ultimate proof that a certain *to-be* scenario indeed performs better than the *as-is* process. Fortunately, in case studies 4, 5 and 8 the performance of the *as-is* process (before intervention) and the *to-be* process (after intervention) has been measured and compared.

5.1 Simulation-Based *To-be* Evaluation

The *to-be* scenarios of case studies 1 to 3 are evaluated in conformance with the fourth phase of the redesign approach. On the one hand, the process owner decides which *to-be* scenarios are most suitable and which performance dimensions, i.e., costs or throughput time, (s)he finds most important. On the other hand, a simulation study is used to determine the key performance indicators for each scenario. For case studies 1 to 3, the simulation results of most of the *to-be* scenarios show an improvement with respect to the chosen performance indicators. In case study 1, for instance, the *to-be* scenario involving the request of the medical file of the patient at referral predicts a throughput time reduction of 13%. The *to-be* scenario of case study 1 involving the empowerment of the intakers to determine the treatment plan predicts a 20% reduction of the throughput time, decreasing the average throughput time from 10 to 8 days [10]. It can, however, not be guaranteed that in real life a certain *to-be* scenario indeed performs as the simulation results indicate. This can only be tested by the implementation of a *to-be* scenario and a measurement of the effect of the change. Based on case studies 1 to 3, therefore, we can only tentatively state that best practices have the potential to be effective.

5.2 *To-be* Evaluation by Post-intervention Measurement

Case studies 4, 5 and 8 include information on the performance of the implemented *to-be* process. The effects of the intervention are evaluated with a before-after design including post-intervention measurements. The post-intervention measurements of case study 4 show that the percentage of patients that can access treatment within 7 days is increased from 60% to 100%. Furthermore, waiting times in the process and the total throughput time are significantly reduced [6]. Case study 5 shows a significant reduction of throughput time (from 37 to 9 days) and the number of visits (from 4 to slightly more than 2) [6]. Case study 8 also describes a before-after comparative study with the goal to maximize MRI capacity. The measurements indicate that the average MRI examination time was shortened by five minutes per patient resulting in an 18% increase in patient throughput for MRI examinations [5]. For the sake of completeness, we note that case studies 6, 7 and 9-14 include mathematical and/or simulation results.

The answer to the question "Is the use of best practices effective?" is that it is *plausible*. Process owners find *to-be* scenarios created with best practices suitable and simulation studies show that such *to-be* scenarios may result in an improvement in performance. Furthermore, post-intervention measurements in case studies 4, 5 and 8 give an improvement in performance which can primarily be attributed to the (implicit) application of best practices. In the next section, we address the third research question and derive additional, specific best practices from the healthcare domain.

6 Derivation of Best Practices

In this section, we address the last research question "Is it possible to extend the set of best practices with the lessons learned from redesigning healthcare processes?". An evaluation of the *to-be* scenarios proposed in the case studies reveals that not all changes are covered by the current set of best practices. Therefore, we revisit the case studies from Table 1 to find the lessons learned and discover new potential best practices. Note that the components of the redesign framework remain unchanged. For each identified potential best practice that we describe next, we include its name and abbreviation, a motivation why it should be included, a qualitative description, its potential effects, and references to related literature beyond the healthcare domain.

Customer Involvement. Hospitals are putting increasing effort into making healthcare more patient-centered. Most improvements, however, have been based on assumptions made by professionals. Therefore, the patient's view should be taken into account when making decisions on redesign priorities [6]. The patient is one of the customers of a healthcare provider. We propose to add the following best practice to the *customer* element of the BPR framework.

INVOL: *Obtain insight in the demands of customers and the added value and bottlenecks as perceived by customers.*

Application of this best practice improves the quality of *to-be* scenarios. The *Customer Involvement* best practice is also mentioned in BPR literature. Harmon [8], for instance, explicitly suggests to ask the customer if it is unclear whether a task adds value or not.

Scheduling. In line with making healthcare providers more patient-centered is the improvement of the scheduling of patients. This is the main conclusion of the review performed by Cayirli and Veral [4] who argue that further research should aim at finding the most suitable support for making appointments. We propose to extend the *behavioral view* element of the BPR framework with the following best practice.

SCHED: *Schedule the least variant patient categories at the beginning of the clinical sessions.*

The scheduling best practice results in a reduction of internal queueing times. Typically, this reduction significantly outweighs the increase in server idle time/ overtime [12].

Resource Joining. Case study 3 explains two situations in which patients leave the oncology dermatology department to go a long way through the hospital for some test and then return to the oncology department again. The *to-be* scenarios for these situations therefore propose to join the responsible resources and place them together in the oncology dermatology department. This best practice is added to the *organization-structure* element of the BPR framework.

JOIN: *Place resources responsible for adjacent tasks (geographically) close together.*

Resource joining reduces the throughput time of the process. Another way to use this best practice is presented by Reijers, Song and Jeong [17]. It would make sense to put human resources, who perform adjacent tasks, near to each other (for instance in the same corridor). Reijers *et al* show that there is a positive effect on the performance if resources are geographically close together [17].

The question "Is it possible to extend the set of best practices with the lessons learned from redesigning healthcare processes?" can be answered positively. We derived three additional, potential best practices of which two seem applicable to other domains as well. It has to be evaluated whether or not these potential best practices are generally applicable to the healthcare domain and beyond.

7 Discussion

The research questions in this paper are formulated in a positive way. It is also possible to formulate them as falsifiable propositions. The first question, for instance, would then be "To what extent are the best practices unsuited for redesigning healthcare processes?". According to our results only a small set of the best practices is not applicable to at least one of the studied processes. The formulation as falsifiable propositions would have led to the same conclusions. Also, a number of potential biases can be distinguished when having a closer look at the research and the used methodology. The first possible bias is a cognitive bias. The developers of the set of best practices are also the evaluators of the suitability of the best practices. This cannot be refuted. Even more so, they are also involved in some of the evaluated case studies. The bias is reduced because the best practices have been published before the case studies were conducted. Therefore, the results of the case studies can be verified by others. Another possible bias is a selection bias. In general, more studies with positive outcomes are published. This cannot be circumvented. A final issue is the small sample size. For our analysis we have used 14 case studies that are selected from the ABI/Inform and INSPEC catalogues and from our own experience. We acknowledge that many more reports on BPR studies in healthcare exist. Another literature review conducted by Elkhuizen [6] selected 86 studies in care process redesign from the Medline, Embase and Ebsco Business Source Premier databases. She categorized the interventions mentioned in the studies which led

to 12 categories. In many of these categories we recognize a relation with one or more of our best practices.

8 Conclusion

In this paper, we have investigated whether the existing set of 29 best practices to support BPR initiatives are applicable to the healthcare domain. From the 14 healthcare case studies that we analyzed, we determined which best practices were applied. Almost three quarters of the total set of best practices was applied in one or more case studies, indicating that the best practices seem highly suitable for the healthcare domain. For three case studies, the outcomes of simulation studies were analyzed, all indicating that the application of the considered best practices would indeed improve most of the identified performance parameters. For three additional case studies, a before-after design study effectively showed a positive impact on the performance caused by the process change. Therefore, the use of best practices appears not only to be feasible but also an effective means to improve process performance. As a final contribution, we proposed an extension of the set of best practices with improvement practices we identified in the analyzed cases. We derived three additional, potential best practices that seem worthwhile to be considered for future BPR initiatives.

In our view, performance improvement initiatives in the healthcare domain can heavily benefit from relying on previous experiences. The best practices that are the focus of this paper form one example of how design knowledge can be re-used, and in such a way can contribute to improved performance. We therefore recommend the use of best practices in healthcare process redesign, while acknowledging the need for an ongoing reflection on and extension with similar heuristics.

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Appendix A: BPR Best Practices [16]

	Customers	
RELOC	Control relocation	relocate control steps in the process to others
REDUC	Contact reduction	combine information exchanges
INTG	Integration	consider the integration with a process of client or supplier
	Operation view	
TYPE	Case types	distinguish separate processes and case types
ELIM	Task elimination	delete tasks that do not add value from a client's viewpoint
CASEB	Case-based work	get rid of constraints that introduce batch handling
TRI	Triage	consider the division of a general task into alternative tasks
COMPOS	Task composition	combine small tasks into composite tasks or vice versa
	Behavioral view	
RESEQ	Resequencing	move tasks to more appropriate places
PAR	Parallelism	introduce concurrency within a business process
KO	Knock-out	execute those checks first that have the most favorable ratio of expected knockout probability versus the expected effort
EXCEP	Exception	isolate exceptional cases from the normal flow
	Organization-structure	
ASSIGN	Order assignment	let workers perform as many steps as possible for single cases
FLEX	Flexible assignment	assign resources in such a way that maximal flexibility is preserved for the near future
CENTR	Centralization	treat geographically dispersed resources as if they are centralized
SPLIT	Split responsibilities	avoid assignment of task responsibilities to people from different functional units
TEAM	Customer teams	consider assigning teams out of different departmental workers that take care of specific sorts of cases
NUM	Numerical involvement	minimize the number of departments, groups and persons involved in a process
MAN	Case manager	make one person responsible for the handling of a case
	Organization-population	
XRES	Extra resources	increase capacity of a certain resource class
SPEC	Specialist-generalist	consider making resources more specialized or generalized
EMP	Empower	give workers most of the decision-making authority and reduce middle management
ADD	Control addition	check the inputs and outputs of a process
	Information	
BUF	Buffering	subscribe to updates instead of complete info. exchange
	Technology	
AUTO	Task automation	introduce technology to automate tasks
TECH	Technology	try to elevate physical constraints in a process by applying new technology
	External environment	
TRUST	Trusted party	replace a decision task by the decision of an external party
OUT	Outsourcing	relocate work to a third party that is more efficient
INTF	Interfacing	consider a standardized interface with clients and partners