PROTOCOL

Matching Registered Nurse services with changing care demands (Match^{RN}): study protocol of a natural experiment multi-centre study

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Abstract

Aim. The aim of this study was to examine how patient safety indicators and processes and structures of nursing care have changed since the 2012 introduction of Swiss Diagnosis-Related Groups.

Background. Diagnosis-Related Groups have been implemented worldwide; yet, research findings regarding their impact on efficiency and quality of care remain inconsistent. The Matching Registered Nurse Services with Changing Care Demands study will assess how structures, processes and patient and nurse outcomes have changed in Swiss acute care hospitals since the introduction of Swiss Diagnosis-Related Groups.

Design. A multi-centre observational study nested in a natural experiment.

Methods. To explore the effect of implementing Diagnosis-Related Groups in Switzerland we will compare nurse and patient survey data from 2010 with data from 2015 and eventually from 2017. Initially, we will match survey data from 78 medical and surgical units of 21 hospitals that participated in 2010 and 2015. Study variables related to structures and processes of nursing care (e.g. staffing/ skill mix level, nurse work environment, rationing of nursing care), as well as patient and nurse outcomes, were assessed with well-established instruments. In 2017, a follow-up survey will be conducted to explore long-term implications. Furthermore, 6 years' medical and surgical patient discharge data (collected 2010–2015) will be analysed to assess changes in the severity of patient illness, length of stay and selected patient safety indicators.

Discussion. This study's results will provide evidence regarding Diagnosis-Related Groups influences on Swiss nursing services and patient safety outcomes.

Keywords: diagnosis-related groups, hospitals, natural experiment design, nursing care, quality of health care, survey, work environment

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Why is this research or review needed?

- The Matching Registered Nurse Services with Changing Care Demands study will evaluate Swiss hospitals' efforts in re-organizing nursing care processes to adapt to the Diagnosis-Related Groups implementation.
- Regarding the long-term effects of Diagnosis-Related Groups, available evidence indicates that changing nursing care structures and processes entails risks both to nurse staffing outcomes (i.e. emotional exhaustion, dissatisfaction with nursing as a profession) and to patient safety (e.g. adverse events).
- The Matching Registered Nurse Services with Changing Care Demands study will provide evidence on Swiss Diagnosis-Related Groups' impact on structures, processes and outcomes relevant to nursing care quality and patient-centred care.

Introduction

For more than 30 years, activity-based funding systems such as Diagnosis-Related Groups (DRGs) have been implemented in healthcare systems worldwide to improve transparency, efficiency and quality of hospital care. Increased transparency is achieved by grouping patient health conditions and medical diagnostic or treatment procedures into categories, thereby allowing comparison of provided services' inputs and outputs. Increased *efficiency* is expected because DRGs incentivize hospitals to increase their financial sustainability either: (1) by increasing the number of patient cases treated; or (2) by reducing the services per case (Geissler *et al.* 2011). Improved quality of care,

including patient safety (Blegen 2006, Zrelak *et al.* 2012) is also expected because hospitals, in their efforts to become more efficient, attempt to improve clinical processes and care management (Or & Häkkinen 2011). However, clear evidence with consistent results regarding DRGs' effects and impacts on efficiency and quality of care are lacking. This study protocol describes the Match[RN] study, which will examine how, alongside processes and structures of nursing care, patient and nurse outcomes have changed since the DRGs were introduced in Switzerland.

Background

In 2012, Swiss Diagnosis-Related Groups (SwissDRGs) were implemented nationally for acute care hospital services in Switzerland. This implementation can be considered a natural experiment, i.e. an event neither planned nor manipulated by researchers, yet reflecting an independent variable influencing one or more dependent variables (Craig *et al.* 2012). Because the implementation decision was made at the cantonal and federal levels, two major criteria of an experimental trial-random assignment and a researcher-controlled intervention, are unattainable.

Quality of the Swiss Healthcare System

Whether observed on its own or in comparison with other countries, the Swiss health system operates at a high level, e.g. regarding patient access to care, health workforce staffing (Aiken *et al.* 2012, Schwendimann *et al.* 2012, Busse 2013). In 2010, Switzerland participated in the international RN4CAST study. A total of 488 acute care hospitals in 11 European countries and 617 more in four US states were included in the sample. In Switzerland, roughly 1600 nurses and 1000 patients from 35 hospitals were surveyed.

By international standards, Swiss hospitals demonstrate high quality of nursing care or high levels of patient safety and a good work environment quality, with high overall nurse work satisfaction (Aiken *et al.* 2012, Schwendimann *et al.* 2012). On a scale of 0 (worst) – 10 (best), 60% of participating patients rated their hospitals 9 or 10, with 78% reporting that they would recommend their hospitals to their families and friends (Aiken *et al.* 2012). The Commonwealth Fund International Health Policy Survey (2011) found that, in a sample of 1500 sicker adults, 69% were satisfied with the Swiss care system (Busse 2013). Switzerland's nurse to patient ratio, which averages one registered nurse per 7·9 patients, is high compared with other countries, leading to high patient satisfaction (Aiken *et al.* 2012). All results above are based on studies conducted before the introduction of SwissDRGs in 2012.

Implementation of the DRGs in Switzerland

Before the implementation of SwissDRGs in Switzerland's 26 Swiss cantons in 2012, four different payment schemes were in use (Meyer 2015). The first, 'process- and performance-based pricing' (PLT, Prozess-Leistungs-Tarifierung), stipulated a fixed amount to be paid prospectively per admitted patient per *day*. The second, 'All Patient Diagnosis-Related Groups' (APDRGs), was a prospective payment per *case* system similar to DRGs, but with an 'additional per diem rate to cover nursing and catering services' (Meyer 2015, p 77). Compared with PLT, APDRGs allowed more precise resource calculation because of specific case weight consideration (Meyer 2015). Third, 'department case-based payments' (DCPs), like PLT, used a fixed prospective amount per *patient* according to the involved department, without the additional per diem rates charged with APDRGs. Fourth, 'per diem reimbursement' was also a prospective system based on the *days* the patient stayed in hospital. Concerning the characteristics of these payment systems, they could be grouped into two main categories: (1) payment per case (APDRG and DCP); and (2) payment per day (PLT and per diem).

Effects of DRGs

Although international research on the effects of DRGs is available, there is no clear evidence on their impact on healthcare structures, processes and outcomes. A systematic review investigate the impact of active-based funding systems on patient mortality, hospital readmission rates and discharge to postacute care settings (e.g. homecare), along with hospital patients' severity of illness and volume of care, compared with that of non-active-based funding systems (Palmer *et al.* 2014). Sixty-five studies (59 with before/after designs, three parallel groups designs, three with before/after and parallel designs) were included in the review. No differences were found regarding mortality; however, where active-based funding systems were used, the authors found increased patient discharges to postacute care settings as well as higher levels of illness severity in hospital patients (Palmer *et al.* 2014). The findings on increased severity of illness indicate that hospitals reduced length of stay (LOS), i.e. by treating patients only during periods of acute illness. Several studies support this finding, including a pre–post study in 297 US hospitals, which pooled data from over 14,000 patients with congestive heart failure, acute myocardial infarction, pneumonia, cerebrovascular accident, or hip fracture and compared patient outcomes before and after the implementation of DRGs. While that study found no differences regarding mortality rates, it did indicate a 24%

LOS reduction following implementation of DRGs (Kahn *et al.* 1990). Similar reductions in LOS have been reported by other American (Schwartz & Tartter 1998, Gillen *et al.* 2007) and European studies (Farrar *et al.* 2009, Geissler *et al.* 2011). However, results regarding patient satisfaction are inconsistent. For example, of three studies examining the effects of DRGs on patient satisfaction with quality of care, two reported lower satisfaction following DRG implementation (Ljunggren & Sjoden 2001, Thommen *et al.* 2014), with the third reporting no change (Farrar *et al.* 2009).

Few studies have investigated DRGs' impacts on nursing care structures and processes. A before/after study examined the effects of the German-DRG system on nurses' practice environments, job satisfaction and emotional exhaustion levels over a period of 10 years (Zander *et al.* 2013). In addition to decreases in nurse staffing issues, their results indicated that, while the quality of collaboration between nurses and physicians increased overall, it decreased concerning perceived respectful and cooperative relationships between the two groups. In addition, following the implementation of DRGs, emotional exhaustion among nurses doubled (from 15% to 30%) and dissatisfaction with the nursing profession increased by 40% (Zander *et al.* 2013). Furthermore, three consecutive nurses' surveys – from 2003, 2006 and 2008 – found similar results in Germany and confirmed increasing incongruity between nurses' perceptions of high quality care and the actual care they could provide (Braun *et al.* 2011). Although research examining the effects of DRGs is limited, the available evidence suggests negative effects on nurse-sensitive patient outcomes and possibly on patient safety.

For Switzerland, few studies have investigated the potential impact of SwissDRGs' introduction, little evidence exists on DRGs' impacts on structures, processes and outcomes relevant to nursing care quality. As the few available studies are limited by their use of parallel group designs before the national introduction (Busato & von Below 2010, Weissenberger *et al.* 2013), small organizational-level samples (Stauber *et al.* 2014, Thommen *et al.* 2014), or descriptive cross-sectional designs investigating professionals' perceptions (Fässler *et al.* 2015, Leu *et al.* 2015), they permit no sound conclusions regarding changes in the outcomes of interest. Match^{RN} will examine how processes and structures of nursing care, as well as patient and nurse outcomes, have changed following the implementation of DRGs in Switzerland and how services can be organized to best respond to changing care demands.

The Match^RN study

Aims

The four specific aims of Match^RN are:

- To describe how the structure of Swiss nursing services (e.g. staffing) and the nursing work environment (e.g. leadership) changed following the introduction of SwissDRGs;
- To describe how processes of nursing care (e.g. rationing of nursing care) changed following the introduction of SwissDRGs;
- To explore how the case mixes of nursing departments (e.g. severity of illness) and nurse-sensitive patient safety indicators (e.g. postoperative complications) changed following the introduction of SwissDRGs; and
- To explore the impact on nursing structures and processes and on outcomes for nurses (e.g. job satisfaction) and patients (e.g. patient safety indicators) following the introduction of SwissDRGs.

Conceptual framework

This study's conceptual framework (see Figure 1) is based on structural contingency theory (Donaldson 2001), Donabedian's Quality Framework (Donabedian 1966) and principles of Lean Management (Kollberg *et al.* 2006). How organizations respond to a major health policy change such as the implementation of DRGs can be described via structural contingency theory (Donaldson 2001). This perspective assumes that organizations fit with their environments (e.g. hospitals fit into the healthcare system), although close fits require adjustments to those environments. In the healthcare context, the quality of an organization's fit is expressed by its performance, e.g. a hospital's level of safety and quality of the care (nurse and patient outcomes) and the efficiency of its service (i.e. on the levels of structure and process) (Smith *et al.* 2009).

Considering research from other countries using DRGs, one expected consequence of the SwissDRG implementation is that patient case mixes will include increasing levels of illness severity, reflecting reductions in LOS. As open systems, hospitals have functional mechanisms to fit them to their environments, i.e. they develop diverse structures and processes to adapt and attain the required performance levels.

Performance in healthcare is commonly described using Donabedian's Quality Framework, which includes three dimensions of care quality: structures, processes and outcomes (Donabedian 1966), overlapping somewhat with structural contingency theory. On the structural dimension, cost containment measures could lead to an overall reduction

of nurse staffing, or replacement of qualified staff with less qualified staff (Sochalski *et al.* 1997). Nurse staffing, including skill mix, has been associated with patient outcomes including mortality, failure to rescue and patient experience with hospital care (Aiken *et al.* 2014, Griffiths *et al.* 2015). Different models of nursing care organization, e.g. the functional or professional model, have been linked to patient safety outcomes such as medication errors or falls (Dubois *et al.* 2013). On the process dimension of care quality, organizational efforts to develop new processes or redesign existing ones are very likely.

One way of describing processes in health care is via the principles of lean management, e.g. value, flow and perfection (Kollberg *et al.* 2006). Value is represented by a service's levels of accessibility and patient centredness (Jackson 2013). Flow refers to the smoothness of the service's operations, which can be measured by waiting times. For example, failures in level scheduling can lead to rationing of nursing care, which has been associated with negative patient outcomes (Ausserhofer *et al.* 2014). Finally, perfection reflects the attitudes and behaviours of nurses to prevent errors, which is expressed, e.g. by the patient safety climate (Huang *et al.* 2010).

Hospitals need to adapt to the DRG introduction by reorganizing their structures and processes of nursing care. Work environment factors, such as organizations' readiness and behaviour in response to change (Weiner 2009) and a supportive nursing practice environment, including, e.g. strong leadership and inter-professional collaboration (Lake & Friese 2006), are important to maintain or regain fit to their changing environments. Adaptations of nursing service structures and processes are associated with patient outcomes (Griffiths *et al.* 2014); and processes, structures and work environment factors are associated with nurse outcomes such as burnout (Aiken *et al.* 2002) and intention to leave (Simon *et al.* 2010), which have long-term consequences regarding healthcare workforce sustainability.

Design and methodology

Match^RN is a 4-year health service research project (2015–2018) to evaluate the effects of SwissDRG implementation in a national sample of acute care hospitals. The study is observational, with multiple data collection periods (2010, 2015 & 2017) and approaches the introduction of SwissDRGs as a natural experiment. Regarding the various reimbursement systems used prior to the nation-wide SwissDRG implementation (see Table 1), hospitals were classed as either under 'DRG-treatment' or as control.
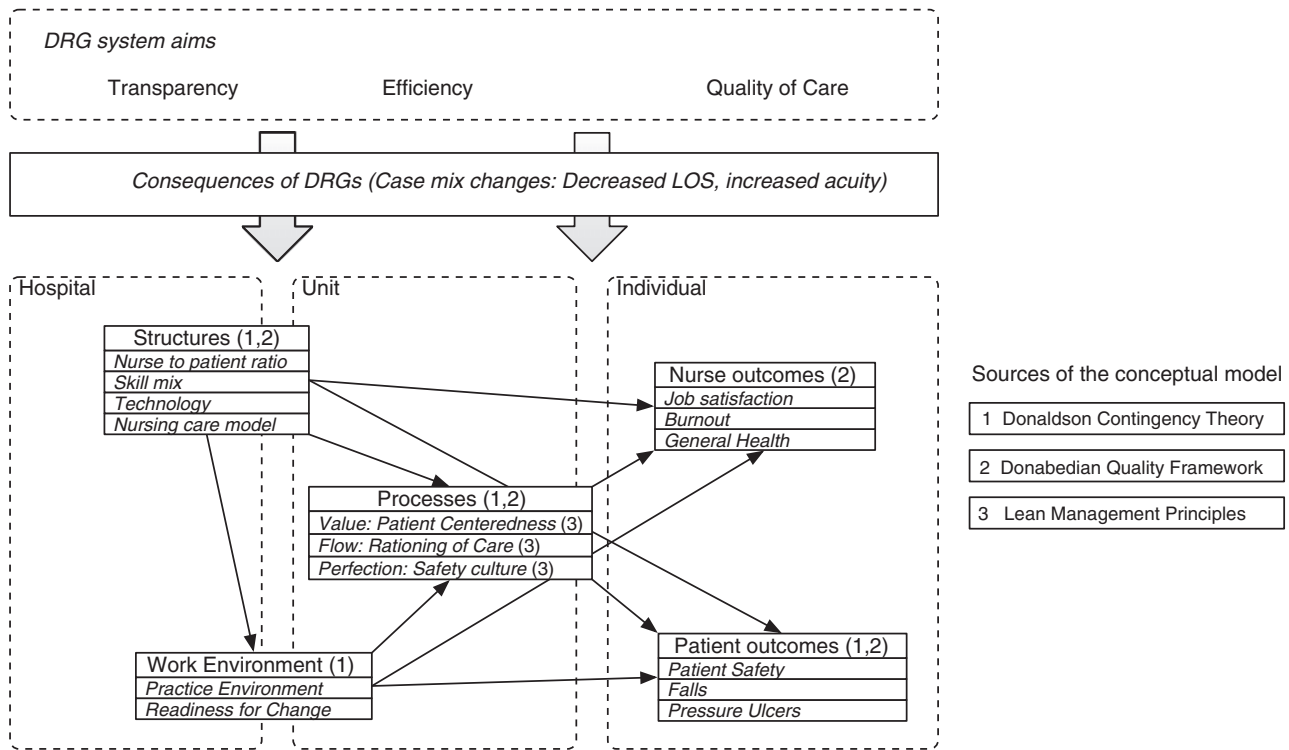
Figure 1 Conceptual model of DRG impact on nursing services' structures, processes and outcome.

Because of variations in cantonal health policy, the assignment to the two groups followed an 'as if' randomization.

Match^{RN} combines 2010 (pre-DRG implementation) patient and nurse survey data from the Swiss arm of the RN4CAST study (Sermeus *et al.* 2011) with post-DRG implementation follow-up data collected for Match^{RN} in 2015 and 2017. The resulting datasets will allow examination of short- and long-term postimplementation changes in structures, processes and outcomes of nursing care.

Table 1 Swiss payments system in 2010 with the number of hospitals, units (divided in identical with RN4CAST and all together in Match^{RN}) and expected nurse and patient questionnaires for Match^{RN}.

Payment system in 2010	Hospital	Units	Nurses	Patients
APDRG	8	32	970	1350
DCP	1	4	280	200
PLT	10	34	1475	1850
Per diem	2	8	315	560
Total identical RN4CAST & Match^{RN}	21	78	NA	NA
Total in Match^{RN}	23	124	3040*	3960*

APDRG All Patient Diagnosis-Related Groups, *DCP* department case-based payments, *PLT* process- and performance-based pricing, *RN4CAST* data collection in 2010, *Match^{RN}* data collection in 2015, *expected.

Moreover, Match^{RN} uses – and will use – routine discharge data provided by the Swiss Federal Statistical Office to assess changes in levels of severity of illness, LOS and patient safety indicators (PSIs), e.g. central line-related bloodstream infections of postoperative sepsis, between 2010, 2015 and 2017. Figure 2 provides an overview of how the study's four aims and various ongoing data sources are interrelated and will inform one another (data collection from 2017 in Figure 2 excluded).

Setting and sample

The study takes place on medical and surgical hospital units. These units serve the highest numbers of patients and the science of measuring structures and outcomes in nursing services is the most advanced in their service lines (Kane *et al.* 2007).

Baseline (pre-SwissDRG implementation) nurse and patient survey data from 2010 were originally collected for the Swiss arm of the RN4CAST study (Sermeus *et al.* 2011). To collect DRG postimplementation data, we surveyed nurses and patients in the same units and hospitals in 2015. In Switzerland, the RN4CAST study applied a quota sampling strategy to include 35 hospitals across the German, French and Italian language regions, representing all types of
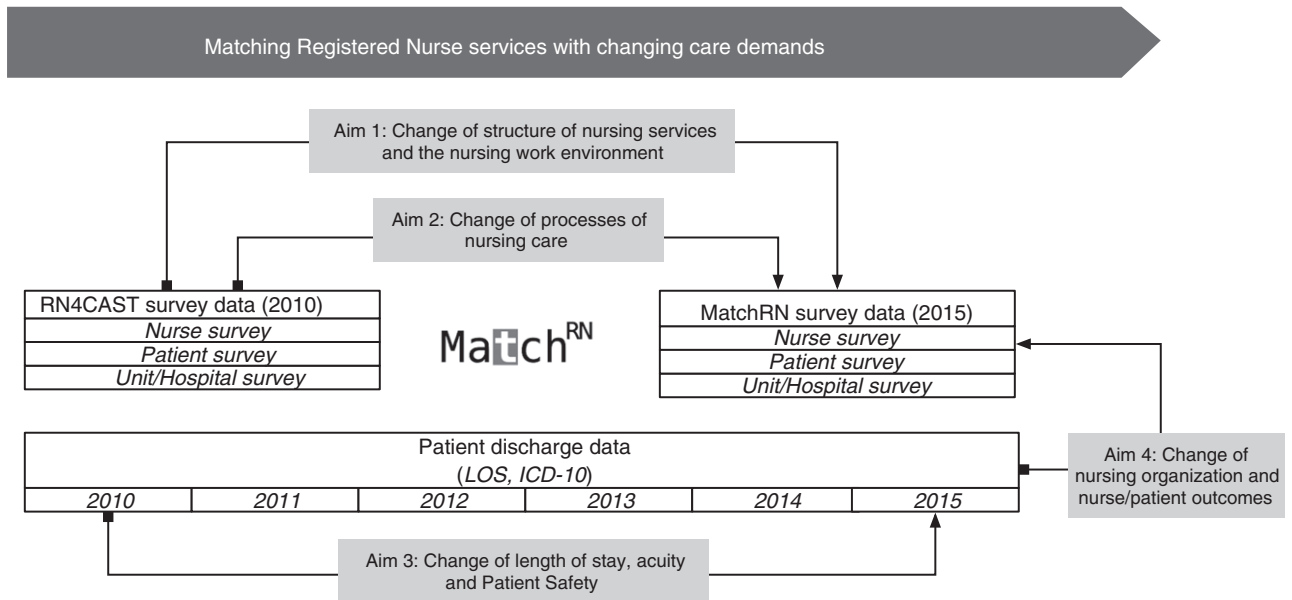
Figure 2 Study aims and relationships between data sources (data collection and sources for 2017 not yet extant).

acute care hospital ranging from small rural hospitals to large university hospitals (Ausserhofer *et al.* 2012). In each hospital, the RN4CAST researcher selected a random sample of medical and surgical units ($N = 132$ units). For Match^{RN}, we invited all of the RN4CAST study's 35 participating hospitals, of which 21 (60%) agreed to participate. Of these facilities' 132 eligible units, 59% (78 units) agreed to participate. In addition, two other hospitals and 46 units volunteered to participate and were included in the study, but were excluded from specific analyses focusing on the before/after aspects of the study. Because of the RN4CAST study's wide range of variables of interest and pre-determined sample, no formal power analysis could be conducted.

Table 1 shows the various reimbursement systems used prior to SwissDRG implementation and the number of hospitals and units that contributed to the RN4CAST 2010 data collection. Regarding the two reimbursement categories we used, nine hospitals, including 36 eligible units, used per-case payment, while 12 hospitals with 42 participating units used per-day payment systems. In addition, Table 1 depicts the expected number of patient and nurse questionnaires, as well as the total sample of hospitals participating in Match^{RN}.

All nurses on the participating units, e.g. registered nurses, certified nurses and nurse aides, were asked to complete the survey. All patients on these units at the time of data collection were also asked to participate, provided they fulfill the inclusion criteria, i.e. they are aged 18 years or older, in sufficiently healthy to participate, have been hospitalized at least 24 hours, understand German, French or

Italian, or have not already completed the questionnaire. Nurses of the respective units recruit the patients, while hospital and unit managers collect administrative data in participating units and hospitals. Furthermore, Match^{RN} uses patient discharge data recorded by all hospitals in Switzerland from 2010 to 2015. On the basis of analyses of the RN4CAST study's 2010 data, we expect to include discharge data from approximately 300,000 patients for each year ($N = 1,800,000$ patients). In 2017, a further survey of patients and nurses in the same hospital units will be conducted.

Variables and measurement

Match^{RN} uses variables and measurements from the following six data sources:

Nurse survey

The Match^{RN} survey is based on the RN4CAST survey (Sermeus *et al.* 2011), with modified scales and additional items. For example, quality of the nurse work environment is measured via a modified version of the Practice Environment Scale of the Nursing Work Index (Lake 2002) and Safety Culture with the Agency for Healthcare Research and Quality (AHRQ) hospital survey on patient safety culture (Blegen *et al.* 2009), the Safety Organizing Scale (Vogus & Sutcliffe 2007) and the Safety Attitude Questionnaire (SAQ) (Sexton *et al.* 2006). In addition, the survey asks for social demographic data (age, gender,

professional experience). The nurse survey contains 177 items across 15 different scales, along with several items revised, adopted and otherwise developed by the Match[RN] study team. Details can be found in Table S1. The scales used have undergone validity and reliability testing and have been used successfully in previous national and international outcome studies (Aiken *et al.* 2002, Sermeus *et al.* 2011).

Patient survey

Match[RN] assesses patient satisfaction via a revised version of the Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey (AHRQ), reflecting patient experiences with nursing care and overall hospital care. Our version includes 12 items, reflecting four domains: (1) nurses care; (2) experiences in the hospital including pain management and communication about medications; (3) received discharge information; and (4) general hospital-related recommendations. Psychometric evaluation of the HCAHPS demonstrated excellent validity (e.g. internal structure) and reliability (e.g. internal consistency) (Jha *et al.* 2008). To reflect patient views on patient centredness of care processes, we use a revised version of the General Short Patient Experiences Questionnaire (GS-PEQ) with 14 items on patient experiences (Sjetne *et al.* 2011). In the Match[RN] study, we will test further psychometric properties of the GS-PEQ. In addition, the patient survey gathers demographic information (age, gender, educational level). Furthermore, with the permission of the EuroQol Executive Office, we included the EQ-5D-3L scale with the five dimensions (mobility, self-care, usual activities, pain/discomfort, or anxiety/depression) and three answer options (no problems, some problems, extreme problems) to assess patient functional status (EuroQol Research Foundation). In total, the patient questionnaire includes 37 items from five different item sources and scales, which were also partly revised and adopted from the Match[RN] study team. Details of the scales can be found in Table S2.

Unit survey

The self-developed nine-item unit survey assesses organizational characteristics of the participating units, such as size (bed count) and service line.

Hospital survey

The hospital survey (13 items) assesses hospital level characteristics such as staffing, grade mix and staff turnover rates.

Hospital statistics

Hospital statistics provided by the Swiss Federal Statistical Office (Bundesamt für Statistik) will provide information about the facility profile including its bed size, ownership status (e.g. privat, not for profit, public) and type (i.e. district, general, teaching hospitals).

Patient discharge data

We will use routine hospital discharge data collected from all Swiss hospitals between 2010-2015 by the Swiss Federal Statistical Office. Although the necessary data are available in two standard versions, researchers are required to negotiate data use agreements to obtain the data with certain specifications. The planned analyses will be dependent on these data use agreements. Hospital data are anonymized concerning both administrative information on patients (e.g. gender, age) and comprehensive healthcare information, e.g. medical diagnoses and interventions during hospital inpatient stays, as well as discharge information. Match[RN] will investigate three areas of interest from discharge data:

LOS: the number of inpatient days will be measured by the difference between the discharge and admission dates +1 day.

Severity of illness will be measured using the Charlson comorbidity index for ICD-10 codes and the Elixhauser comorbidity index (Elixhauser *et al.* 1998). The c-statistic will be used to select the most valid measure for the PSIs.

PSIs of AHRQ will be assessed using those indicators found most nursing sensitive (Zrelak *et al.* 2012): (a) central line-related bloodstream infection; (b) postoperative sepsis; (c) postoperative deep vein thrombosis and pulmonary embolism; (d) postoperative respiratory failure and (e) pressure ulcers. The measurement of PSIs is based on an algorithm using International Classification of Diseases, 10th revision (ICD10) codes, including a selection of secondary diagnoses in the numerator (to identify potentially relevant hospital-related adverse events) and DRG, ICD or/ and procedure codes (CHOP) in the denominator to define the population at risk (Januel 2011). The population at risk in the PSI denominator may vary according to the inclusion and exclusion criteria of the respective PSIs (e.g. for pressure ulcers, patients with LOS <5 days, with a diagnosis of skin disease in any coding field and who are admitted with the principal diagnosis of pressure ulcer, will be excluded from the denominator).

Survey translation and validity testing

Original English language scales and items, which are not available in German, French or Italian, have been translated first into German using a modified Brislin protocol, a

systematic translation process (Jones *et al.* 2001). French and Italian language versions were translated from the German version using forward-backward translation. After this, an expert panel review of bilingual clinical and research nurses fluent in each target language reviewed each item regarding cultural adaptations. To ensure comprehensibility and to check for response patterns, the entire German and French versions of the nurse questionnaire were pilot tested with nurses with a range of educational levels. Likewise, the full German and French language versions of the patient questionnaire were pilot tested with patient volunteers. Experienced nurses reviewed the Italian language versions. For all language versions of both the nurse and patient questionnaires, adaptations were made as necessary for wording and clarity.

Data collection

The data collection followed the same procedures as used in the RN4CAST study (Ausserhofer *et al.* 2012). Between September 2015–January 2016, all participating hospitals and units received the questionnaires, including postage-paid return envelopes. Completed questionnaires were either returned directly to the study team by normal post or first collected in boxes placed on each unit, then returned by the unit coordinator.

For the nurse survey, the unit coordinators distributed the questionnaire to all nurses of the participating units. To allow follow-up of response rates and posting of reminders, we asked all participating hospitals to provide the number of nurses employed on each participating unit. For the patient survey, Match^{RN} took a day census approach. In each unit, on two randomly selected working days (with an interval of at least 2 weeks) during the study period, the contact person (e.g. the unit coordinator or a nurse specialist) invited all eligible patients to complete the questionnaire. Each questionnaire included a unit-specific code, allowing us to check response rates. For the patient survey, on units with fewer than 10 responses after two data collection days, a third randomly selected data collection day was permitted.

The unit and hospital managers completed the surveys for their respective organizational levels. A data entry service will manually enter all questionnaire data into a database. Further data collection for the Match^{RN} study will be conducted in 2017 on the same hospital units.

Furthermore, we will use hospital statistics and hospital routine discharge data from all Swiss hospitals between 2010 and 2015. This data will be obtained directly from the participating hospitals or from the Swiss Federal Statistical Office after concluding a data privacy contract.

Data analysis

To deal with risks inherent in natural experiments, e.g. 'selection on observables,' we will use a regression analysis or propensity score matching approaches. In contrast, 'selection on unobservables' risk refers to situations when variable that cannot be observed directly are associated with the dependent variable but unevenly distributed across the groups (pre–post-SwissDRG implementation). In these situations, instrumental variable, regression discontinuity or difference in differences approaches are suggested (Craig *et al.* 2012). Regression discontinuity designs require a clearly defined step change, which did not occur with the SwissDRG introduction. Changes to care structures and processes are likely to evolve over longer periods with no clearly defined step change; and some Swiss cantons introduced SwissDRGs before their national implementation in 2012. Another alternative would be instrumental variables (Greenland 2000), which proved difficult to identify in the context of this study. Therefore, a difference in differences approach, which compares changes over time in exposed (SwissDRG) and unexposed (non-SwissDRG) groups, offers the most promising strategy to overcome possible selection bias on unobservables. Consequently, the comparison of changes of severity of illness, LOS, PSIs and nurse outcomes will be possible between cantons with DRGs already implemented in 2010 (parallel design in RN4CAST data) and those that waited for the national implementation in 2012 (RN4CAST data vs. Match^{RN} data).

In accordance with our study aims, Match^{RN} involves the following descriptive and inferential statistics:

Aims 1 and 2

We will compute descriptive statistics to describe the sociodemographic and professional characteristics of nurses and variables related to the structure of nursing services and the quality of the nurses' work environment. For these analyses, the study team will complete two basic steps: (1) genetic propensity score matching with balance optimization (Sekhon 2011); and (2) hidden bias assessment with Rosenbaum bounds (Rosenbaum 2002). The matched analysis will account for clustering at the unit and hospital levels via multilevel analysis (Snijders & Bosker 1999).

Aim 3

Considering the sample and the types of changes involved in this natural experiment, two types of variation are expected in this study: (1) those between pre- and post-SwissDRG periods; and (2) those between hospitals as

random-effect variations. The evaluation examines potential measurement variations that could be explained by various fixed-effect factors related to case mix (e.g. gender, age) and hospital characteristics (e.g. hospital size). We will use hierarchical generalized linear models – an extension of generalized linear models that allows the dependent variables a variety of error structures, including normal, binomial and Poisson distributions.

Aim 4

Using hierarchical generalized linear models, Match^{RN} will assess potential associations between structures and processes of nursing care and three types of outcomes: (1) LOS; (2) PSIs and (3) nurse outcomes (i.e. job satisfaction, burnout and turnover intentions).

For statistical analyses we will use open source software R Version 3.3.2 for Mac OS X.

Ethical considerations

Because of the Match^{RN} study's observational and anonymous data collection approach, it received exempt status approval from all ethics committees responsible for the 23 participating hospitals, all of which their provided informed consent to participate. Nurse and patient participants received the questionnaire with a covering letter introducing the study's purpose, explaining and guaranteeing the protection of their anonymity and emphasizing that participation is voluntary. To protect the anonymity of all individual participants, we will apply relevant protection mechanisms (e.g. coded dataset numbers, secured data storage). Participation in both the nurse and the patient survey is voluntary; filling out and submitting the questionnaire will be considered as informed consent. Patient discharge data will be requested from the Swiss Federal Statistical Office. As these data are not linkable to any patient names, anonymity is fully guaranteed.

Validity and reliability

Several steps have been taken to ensure the validity and reliability of the study. First, data collection employed established or pre-tested instruments. For scales used for the first time in Switzerland, we will test reliability e.g. using factor analyses and Cronbach's alpha. For translation of the scales, we conducted a systematic backward-forward translation process. For all language versions of questionnaires, we asked experts for feedback to explore face validity. In addition, the questionnaires were pilot tested with appropriate target groups.

Second, to deal with common problems of observational studies, the omission of important confounders (e.g. unobserved confounders in one group and the strength of the effect of the unobserved confounder), we will conduct sensitivity analyses to determine the robustness of effects (Schwartz & Ash 2013) and the extent to which plausible changes of assumptions affect conclusions (Rosenbaum 2002).

Stakeholder involvement

Match^{RN} will build on the RN4CAST project's established stakeholder group, with 'the ultimate goal…[of] engaging stakeholders to create a common understanding by soliciting knowledge, experience, judgment and values' (Deverka *et al.* 2012, p. 5). Since the start of this research project, we have established a panel of more than 15 stakeholders, including regional and national level representatives of nursing, consumer and healthcare organizations.

Discussion

Benefiting stakeholders in the Swiss healthcare system, including policy makers, hospital managers, healthcare professionals and the general public, Match^{RN} will provide new knowledge on how care has changed in Swiss hospitals since the implementation of SwissDRGs. Such knowledge will provide the basis for policy briefs, deliberative dialogues, public discussions and organizational learning based on the strategies of 'best performing' hospitals.

Despite several studies on the implementation of the SwissDRG policy, levels of certainty remain low concerning how DRGs have influenced the overall quality of hospital care regarding structures, processes or outcomes of nursing services. Match^{RN} will help to address this knowledge gap by identifying both changes in nursing practices and how those changes have influenced the quality of patient care. Beginning with a clear perspective on nursing services, including the nursing work environment and patient outcomes, the results will inform the health policy community about DRGs' impact on the quality and safety of Swiss patient care.

Limitations

Because of its natural experiment design and the resulting lack of random assignment, concurrent control groups and researcher-controlled interventions, Match^{RN} has a risk of selection bias (i.e. selection on observables and unobservables). We will address this potential bias by following the Medical Research Council's recommended strategies, including multiple pre/post measures, the use of multiple

exposed and unexposed groups, measurement of confounders and combinations of these methods, as well as analytical approaches, e.g. propensity score matching and difference in differences analysis (Craig *et al.* 2011).

Conclusion

Match^{RN} is a highly relevant and timely health service research project that investigates the impact of the 'natural experiment' of SwissDRG implementation. Based on a large multi-centre sample of more than 21 hospitals across Switzerland's German, French and Italian regions, the proposed research project will contribute to the literature on DRGs and will allow the expansion of research capacities and collaboration in health services and nursing research.

Conflict of interest

No conflict of interest has been declared by the authors.

Author contributions

All authors have agreed on the final version and meet at least one of the following criteria [recommended by the ICMJE (http://www.icmje.org/recommendations/)]:

- substantial contributions to conception and design, acquisition of data or analysis and interpretation of data;
- drafting the article or revising it critically for important intellectual content.

Supporting Information

Additional supporting information may be found online in the supporting information tab for this article.

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