

# How to measure innovation in radiotherapy: an application of the Delphi method

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## ORIGINAL ARTICLE

# How to measure innovation in radiotherapy: an application of the Delphi method

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## ABSTRACT

**Objective:** Innovation is an important driver for improving the quality of health care, yet a tension exists between innovation and providing cost-effective health care. To develop strategies that promote innovation, parameters are needed that are indicative of innovation. However, no recognised indicators of innovation in radiotherapy are currently available. The aim of this study is to fill that gap by providing a framework for measuring innovation. This should facilitate future multi-centric studies on strategies aimed at promoting innovation in radiotherapy.

**Methods:** We applied the Delphi method in four rounds. The chairpersons of all Dutch radiotherapy departments were asked to suggest indicators. The resulting inventory was assessed by a number of Dutch radiation oncologists, medical physicists and managers. After implementing a cut-off score on suitability and measurability, we asked Dutch professors on innovation to assess the remaining indicators. Finally, the chairpersons reached consensus.

**Results:** On the basis of the Delphi study, we derived 13 indicators in four categories, more specific product innovation, technology innovation, market innovation and organisational innovation, for measuring both incremental and radical innovations in radiotherapy; these indicators are also suitable for measuring the generation and adoption of innovations.

**Conclusions:** We were successful in reaching consensus amongst the experts on indicators that measure innovations in radiotherapy. The developed tool will be used to investigate the relation between innovation and possible factors inhibiting or stimulating successful innovation and between the level of innovation and its effects.

**Key Words:** Innovation, Radiotherapy, Delphi method, Innovation indicators, Innovation measures

## 1. INTRODUCTION

As in general healthcare, there is an increasing pressure in radiotherapy to deliver cost-effective treatment.<sup>[1]</sup> This pressure threatens the continuous development and implementa-

tion of innovations, and thereby the quality of radiotherapy, since innovation has been shown to be an important driver of quality care.<sup>[2-9]</sup> Technological innovations in radiotherapy have, for instance, resulted in better treatment outcomes by

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fostering the ability of radiation oncologists to deliver radiation more precisely, increasing the dose to tumour targets and reducing the dose to normal tissues and critical structures.<sup>[10,11]</sup> This is in line with findings in general hospitals; Wu *et al.*, for example, have shown that medical and administrative innovations have a positive effect on care outcomes.<sup>[9]</sup> The tension between cost containment and innovation can be felt at several levels.

First of all, the tension between innovation and cost containment arises in particular in situations where innovations and daily practice are integrated, as is the case in many radiotherapy departments, which are often affiliated to or embedded in a university medical centre.<sup>[12-14]</sup> Whereas efficiency requires standardisation and meta-routines for non-routine activities, small-step or incremental innovations call for experimentation (on existing practices) and experience-based approaches.<sup>[15,16]</sup> To develop and implement innovations, treatment processes are in constant evaluation and experiments must be conducted to improve processes and treatments. Such an approach demands additional means and experimentation time, which could be regarded as a waste if the experiment turns out to be unsuccessful.

Second, the organisational conditions and organisations' management styles vary from efficiency-oriented to more experiment-oriented organisations. In an efficiency-oriented setting, monitoring, controlling and a coordinative management style are required.<sup>[17]</sup> In an experimental setting, a consultative, coaching management style is more suitable.<sup>[18]</sup> If an organisation strives to make not just incremental but also more radical and major innovations, the demands for organisational conditions and management style will change again, as new external knowledge has to be imported. An adhocratic, entrepreneurial and visionary management style is paramount when radical innovations are to be made, because this can encourage employees to move across organisational and technical boundaries.<sup>[15,17,19]</sup>

A third aspect that influences the degree of tension, is the distinction between generating innovation by means of research and adopting innovations. Some experts suggested that innovation refers solely to the implementation of new or significantly improved treatment or technologies. Others state that innovation can also refer to research that generates new knowledge. This distinction is important because generating innovation requires different conditions than implementing innovations or improving efficiency.<sup>[14]</sup> Aiming for all these aspects simultaneously might cause tension in the organisation, because of conflicting requirements.

Since continuous innovation is essential for improving the quality of care,<sup>[2-9]</sup> the tension between cost containment

and innovation as described above needs to be handled adequately. Organisations that are more successful in this respect may for example adapt their management style to the situation at hand.<sup>[20]</sup> To investigate which strategies are effective in stimulating different kinds of innovations, measurable and validated indicators are needed to measure innovation. These indicators could help organisations to develop and monitor their innovation ability and practices, by clarifying what they need to focus on in order to maximise their innovation success rate.<sup>[21]</sup> Because our research concerns the field of radiotherapy, we need to find indicators that are suitable for measuring innovation in radiotherapy centres.

In literature no closely defined or generally accepted approach has been found for measuring innovation in general.<sup>[8,21-23]</sup> For the service sector, to which health care including radiotherapy more or less belong, indicators have been developed and listed in the Community Innovation Survey (CIS).<sup>[24]</sup> The development of the CIS was instigated by the European Commission, as a follow-up of the OECD initiative (Organisation for Economic Co-operation and Development) to develop a manual for a survey on innovation. The guidelines of the OECD manual only comprised manufacturing activities and technological and product innovation.<sup>[25]</sup> However, the CIS also has limitations in the sense that it is focussed on technological innovation and concentrates mainly on business services and not on health care.<sup>[26,27]</sup> Previous research has emphasised that a sector-specific measurement tool is needed "in this case radiotherapy-specific" because activities can vary greatly within the different service sectors.<sup>[28]</sup> Furthermore, measurement tools have to render a very exact measurement of what is most important in a certain innovation phase in a particular sector, and register specific characteristics such as knowledge-intensity.<sup>[21,29]</sup> Finally, embedded knowledge must be measured as well; this is knowledge that is not codified but is "stored" in individuals' minds or organisational routines.<sup>[21]</sup>

Several studies on innovation indicators have been conducted which show that, over time, innovation indicators have evolved, becoming progressively more complex and meaningful.<sup>[21,30,31]</sup> In fact, there are potentially hundreds of indicators imaginable. Which indicators are most suitable for measuring innovation in a specific situation or sector is still debatable, however, and needs to be clarified in each specific sector and situation such as in our case in radiotherapy.<sup>[32,33]</sup>

The aim of this study is to identify indicators of innovation that are suitable for measuring innovation in radiotherapy. It is required that these indicators can be applied in a multi-centric setting, can capture both incremental innovation and more radical innovations, and can distinguish between generating and implementing innovations.

## 2. METHODS

We applied the Delphi method to identify the indicators with four rounds (see Figure 1).<sup>[34,35]</sup> This method makes it possible to consult both experts in the field of radiotherapy and experts in the field of innovation (professors with a chair related to the field of innovation). This method has been successfully followed in radiotherapy research as well as other research fields.<sup>[36-42]</sup>

Since no patients were involved in our surveys, the law in the Netherlands does not require ethics clearance.

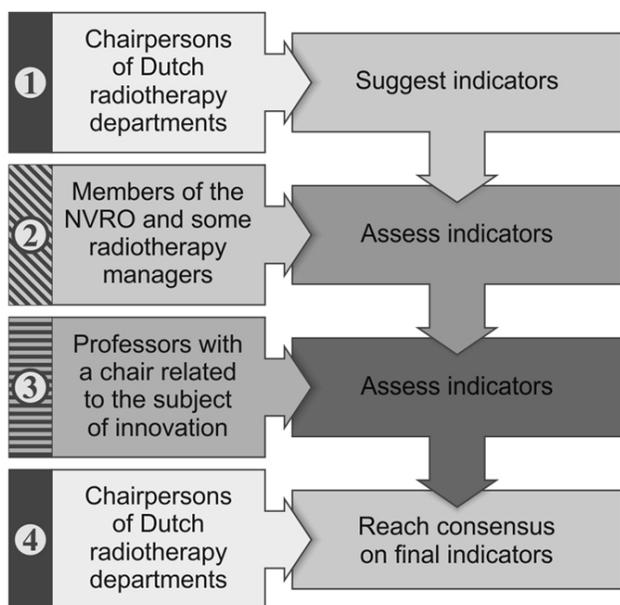


Figure 1. Overview of the Delphi rounds

### 2.1 Round 1

#### 2.1.1 Methods and materials

Based on literature, we distinguished four types of innovation.<sup>[43]</sup> For each type of innovation, we started by defining a few indicators in a brainstorm session in our clinic (MJ/LB/AD/PL). These indicators were put together in a questionnaire, sent out in Round 1 to the chairpersons of all 21 Dutch radiotherapy departments (experts in radiotherapy). The chairpersons were asked to agree or disagree with the indicators listed and to suggest additional indicators.

#### 2.1.2 Data analysis

All suggested indicators were included in the next round without further assessment.

### 2.2 Round 2

#### 2.2.1 Methods and materials

The indicators (96) suggested by participants in Round 1 were put in a questionnaire. The questionnaire was sent to a group of 330 people, mainly members of the NVRO (the

Dutch Society for Radiation Oncology) and a small number of managers active in the radiotherapy domain (also experts in radiotherapy). These people were asked to rate each indicator on its suitability and measurability. A 5-point Likert scale was used for all answers; participants could also add comments of their own. To improve the response rate, two questionnaire reminders were sent out.

#### 2.2.2 Data analysis

We ranked the indicators obtained in the second round on the basis of agreement of the scores assigned by the respondents. To do this, we calculated the mean scores and interquartile ranges (IQR).<sup>[44]</sup> The IQR is the absolute value of the difference between the 75<sup>th</sup> and 25<sup>th</sup> percentiles, with smaller values indicating a higher degree of consensus.

Indicators were selected on the basis of a cut-off: a mean score of  $\geq 3.00$  for suitability,  $\geq 3.50$  for measurability and an IQR of 2. This cut-off value was chosen in a way that the number of indicators was reduced to the most suitable and measurable ones; literature shows that it is important to keep the list of indicators as short and simple as possible.<sup>[45]</sup> Because suitability was also assessed by the innovation professors (which also reduced the number of indicators to the cut-off), we decided to set the cut-off for measurability at 0.5 higher than for suitability. We used a box-plot analysis to determine whether the experts differed in their opinions on the suitability and measurability of the indicators.

### 2.3 Round 3

#### 2.3.1 Methods and materials

We sent a questionnaire to 26 innovation experts (all Dutch professors with a chair related to the field of innovation, as described on their universities' websites), asking them to approve or reject the indicators suggested by the radiotherapy experts, so as to obtain greater certainty that the indicators did indeed measure innovation.

#### 2.3.2 Data analysis

We decided to accept an indicator if it was not rejected by the majority of the Round 3 innovation experts assessing the indicator. To promote consistency in terminology, we reformulated some of the indicators.

### 2.4 Round 4

#### 2.4.1 Methods and materials

We sent a questionnaire to the Round 1 chairpersons of radiotherapy departments if they agreed with the indicators chosen in the previous rounds.

#### 2.4.2 Data analysis

Research into Delphi studies shows that no clear criteria are available for the moment when consensus is reached.<sup>[46]</sup> We

decided that consensus had been reached when 80% of the Round 1 respondents agreed that the selected indicators were good measures for the four types of innovation, because this is the percentage that is usually applied.<sup>[36]</sup> After consensus was reached, the Delphi study was closed.

### 3. RESULTS

#### 3.1 Response rate

In Delphi Round 1, 15 of the 21 chairpersons from the radiotherapy departments we approached accepted the invitation to participate in our study; one person asked if they could skip Round 1. In the end, 14 chairpersons responded to the questionnaire on indicators.

The Round 2 questionnaire had a 20% response rate, and was completed by 66 of the 330 invited NVRO members/managers of radiotherapy departments. An additional 56 of the 330 invitees (17%) stated their reason for not participating in the study.

In Round 3, 18 of the 26 professors with a chair related to innovation who we approached gave an initial reply. Four of these professors added comments but made no assessment, while another four people stated that, due to circumstances, they had no time to participate. In total, 10 of the 26 professors we approached assessed the indicators.

In Round 4, 14 of the 15 chairpersons of Dutch departments of radiotherapy reached an agreement on the indicators sug-

gested in the previous rounds.

#### 3.2 Indicators for innovation

Round 1 resulted in a lot of possible indicators (96 indicators).

The analysis of the Round 2 assessments resulted in 17 remaining indicators. After comparing these indicators with the literature, we moved one indicator from “product innovation” to “technological innovation”.<sup>[47]</sup> The box-plot analysis showed that there were no significant differences between the appraisal by different professionals ( $p > .05$ ).

In Round 3, the professors we consulted varied in their opinion on the indicators suggested. In some cases, the professors suggested we reword an indicator. We reformulated some of the indicators to make them more consistent. We used the wording chosen in the CIS for a number of comparable indicators. Because only one indicator remained for organisational innovation, we also added some relevant indicators from the CIS to our list.

In Round 4, 14 of the 15 chairpersons responded to the list resulting from Round 3. The experts all approved of the indicators suggested, which renders a 93% consensus, far more than the required 80% usually applied in Delphi studies.<sup>[36]</sup> Figure 2 presents an overview of the radiation-oncology-related indicators of innovation that were finally agreed upon.

Product innovation	Technological innovation	Market innovation	Organisational innovation
<i>during the past three years</i>	<i>during the past three years</i>	<i>during the past three years</i>	<i>during the past three years</i>
<ol style="list-style-type: none"> <li>Number of introductions of new or significantly improved treatments <ul style="list-style-type: none"> <li>New to radiotherapy</li> <li>New to your clinic</li> </ul> </li> <li>Number of new positioning devices for patient treatment (e.g. a new fixation product)</li> <li>Number of approved patents (available from a public database)</li> <li>Percentage of patients in phase III randomised trials approved by an IRB (Institutional Review Board)</li> <li>Percentage of patients in phase I-II trials approved by an IRB (Institutional Review Board)</li> </ol>	<ol style="list-style-type: none"> <li>Frequency of implementation of new medical devices</li> <li>Number of products (e.g. hardware, software) for which royalties have been obtained or which have been sold to the industry</li> <li>Number of CE (Conformité Européenne) marked products (e.g. hardware, software) that have been produced by the department</li> </ol>	<ol style="list-style-type: none"> <li>Percentage of patients from outside the market area</li> <li>Number and percentage of new general hospitals that refer the desired patient population</li> </ol>	<ol style="list-style-type: none"> <li>New practices for organising procedures (e.g. management of the total care chain, redesigning treatment process, knowledge management, lean production, quality management)</li> <li>New methods of organising work responsibilities and decision making (e.g. first use of a new system of employee responsibilities, teamwork, decentralisation, integration or decentralising departments, education/training systems)</li> <li>New methods of organising external relationships with other organisations or public institutions (e.g. first use alliances, partnerships, outsourcing or sub-contracting)</li> </ol>

**Figure 2.** Overview of radiation-oncology-related innovation indicators on which consensus was reached in the final round

## 4. DISCUSSION

This paper describes the first attempt to develop a set of indicators that measure innovation in radiotherapy. Our Delphi study design seems to have been an effective tool for generating such indicators. Unlike the approach taken in most Delphi studies, we included experts from different disciplines, namely, the fields of radiotherapy and innovation.<sup>[37]</sup> The advantage of taking this approach was that we could combine the knowledge and insights from experts in radiotherapy with those from experts in the field of innovation. We considered it important to apply such an integrated approach, because as yet no clear picture of innovation exists in the literature, or in the fields of innovation and radiotherapy.

The indicators of innovation we developed could be applied in future studies aimed at analysing and quantifying the aspects of innovation that are either present or absent in radiotherapy departments. The indicators could subsequently be used to find the keys to improving innovation. The latter in particular would be extremely useful, as innovation is often thought to be related to the quality of care.

### 4.1 Views on innovation in radiotherapy derived from the literature

Innovation is a complex concept.<sup>[48]</sup> The literature on innovation is extensive, offering many different, but often vague definitions.<sup>[15]</sup> Indeed, only a few well-designed studies on health care can be said to exist.<sup>[49]</sup> A frequent problem is that often it is not clear from which viewpoint innovation is being approached. For example, the focus of study can be on the process of innovation, the degree of novelty of the end-product, product content or organisational competence.<sup>[15]</sup>

In our study, we decided to select the three viewpoints we assumed to be most relevant for the development of measurement indicators. The first viewpoint concerns *the type of innovation*. Describing innovation on the basis of the type of innovation was done as early as 1934, and has had widespread applications since then.<sup>[43]</sup> In this view, a distinction is made between innovation as concerning new products (*e.g.* in radiotherapy new treatments such as stereotactic body radiation therapy have been introduced), new technology or production methods (*e.g.* new planning methods, such as atlas based planning), new markets (*e.g.* a new hospital referring patients), new forms of organisation (*e.g.* a lean redesign), or new sources of supply of raw materials or half-manufactured goods (in radiotherapy, an example could be that of using a mouldable rubber bolus instead of the outmoded wax bolus). The last type of innovation, introducing new sources of supply, does not occur frequently in radiotherapy, which is why we excluded this type from our study. All other types are included.

The second viewpoint concentrates on *the innovation competence* of the organisation and makes a distinction between *generating* innovation by means of research and the adoption of innovations by organisations or units.<sup>[14]</sup> Distinguishing between the generating and adopting innovations is essential, because the organisational conditions required for each activity can vary considerably.<sup>[15]</sup> As a consequence, organisations that both try to generate and adopt innovations could experience tension in daily practice. Further research needs to point out whether this is actually the case.

The third and final viewpoint centres on *the degree of innovation*, with a special focus on radical innovation (innovations which discontinue the existing practice of treatments, technology, markets or organisational behaviour, systems, structures and so on) in knowledge-intensive firms.<sup>[15]</sup> We believe that radiotherapy centres can be characterised as such. The MR-linac (completely new radiation equipment) is an example of such a radical innovation in radiotherapy.

As a last point to mention, the innovation process itself is not considered in this study, as our main interest lies in measuring the outcome of innovation.

### 4.2 First viewpoint: types of innovation

To categorise the indicators, we applied the first viewpoint. The professionals participating in the study were asked to submit indicators for each type of innovation. Below, we describe the types of innovation distinguished by converting them from Schumpeter and the third edition of the OECD manual to radiotherapy.<sup>[43,50]</sup> We also compare our indicators with previous findings from the literature.

- *Product innovation can be described as* the introduction of treatments that are new or which constitute a significant improvement in terms of their characteristics or intended use. Such innovations include improvements in technical specifications, components and materials, incorporated software, user-friendliness and other functional characteristics. Product innovations sometimes utilise new knowledge or technologies.

We found five indicators for this type of innovation. Similar indicators are found in the literature.<sup>[20,30,31]</sup>

Our list contains a patent indicator. In the literature, there is some discussion about the appropriateness of this indicator. A systematic relationship has been found between an organisation's innovation output and its actual patenting behaviour.<sup>[51]</sup> The correlation between these two factors is far from perfect, however. This might be due to research and development collaboration interfering with the correlation: contract

research may result in patents being assigned to the one who pays for the research rather than the hospital which first registered the patent. Sometimes, too, it is said that services (to which the hospital sector belongs) tend to apply more frequently for copyright than for patents.<sup>[26]</sup> Despite these considerations, we decided to keep the indicator on the list; as the discussion above implies, having no patents as a clinic does not necessarily mean that no innovation takes place. On the contrary, if patents are assigned to a clinic, this could be characterised as a form of innovation (generating innovation).

- *Technological innovation* is the implementation of a new or significantly improved treatment process or delivery method that has no noticeable consequences for the end-product. Technological innovation includes significant changes in the techniques applied, the equipment used or the available software. In our study, we decided to classify a new method as a technological innovation only if it led to renewal of the production process or constituted a significant improvement, without immediate and noticeable consequences for the patient. We also proceeded from the view that the acquisition of entirely new equipment or devices should always be labelled as technological innovation, irrespective of the effects on the patient - except when a completely new treatment is introduced, for example, using protons.

Our indicators of *technological innovation* concur with the Schumpeterian definition, because they all refer to production methods. In the literature, input indicators such as Research & Development expenditures are sometimes used to measure technological innovation. However, as stated, in recent years output indicators have been described as being more suitable.<sup>[32,52]</sup> Studies on technological innovation often focus on manufacturing, and examples of the output indicators used in these studies all refer to production methods, such as new production techniques, automation, and fundamentally new production systems.<sup>[53]</sup> In addition, output indicators of device innovation are often used, such as the number of products regulated by the FDA for medical devices (comparable to the European indicator of CE [Conformité Européene] marking).<sup>[54]</sup>

Lastly, there exists a body of literature on Literature-Based Innovation Output (LBIO) indicators that are generated by sampling the “new product announcement” section in technical and trade journals, a method

which is also applied in public services.<sup>[48,52]</sup> Converting this procedure to radiotherapy is not impossible, but it would be very complex and labour-intensive.

- *Market innovation* refers to new patients, and includes the opening up of a new hospital market in which the relevant clinic has not operated before. When it comes to market innovation indicators, our findings bear a close similarity to the results from previous research, such as the reports on “new customers gained through innovation” and “number of new customers of new products/services who go on to buy existing products/services”.<sup>[55]</sup>
- *Organisational innovation* is the implementation of new or significant changes in clinic organisational structure or management methods aimed at improving the use of knowledge, the quality of treatments and services, or the efficiency of workflow. Such changes can include new practices of organisation procedures, new methods of organising work responsibilities and decision making, and new methods of organising external relationships with other organisations or public institutions.

Research on defining and measuring *organisational innovation* is still lacking due to a lack of empirical data, clear definitions and suitable measurement constructs.<sup>[56-58]</sup> Organisational innovation is often rather broadly defined, and indicators vary greatly.<sup>[57]</sup> An additional complexity is caused by the different types of organisational innovation that can be discerned, the long lifecycle of organisational innovations, differences in the extent of use and implementation of such innovations, and also by the fact that certain labels (*e.g.* teamwork) are differently formulated across organisations. The professors in innovation rejected three of the four indicators of organisational innovation. Strikingly, the radiotherapy experts, who have no theoretical background in innovation concepts, were able to formulate appropriate product, technology and market indicators, although they failed to formulate acceptable organisational indicators. The possible reason for this is that most radiotherapists focus on innovation within the content of radiotherapy, rather than on the processes that facilitate organisational innovation.

### 4.3 Second viewpoint: innovation competence

The second viewpoint we considered relevant for radiotherapy concentrates on how organisations or units generate and adopt innovations, which can be helpful for answering the question whether research can be seen as innovation.<sup>[14]</sup> Two

of the professors in innovation stated explicitly that implementation is a “*conditio sine qua non*” to classify something as an innovation; however, other professors approved our two research indicators of trials and patents, which pertains to innovations that are not necessarily implemented in practice. The question arises whether new knowledge that results from research but is not yet implemented in clinical practice must be considered as innovative. To answer this question, we applied two insights from the literature. First of all, sometimes a distinction is made between invention and innovation, with invention being the first mention of an idea for a new product or process, whereas innovation applies to the first time that an idea is commercialised.<sup>[47]</sup> Although invention and innovation are sometimes hard to distinguish from each other, often there is a considerable time lag between the two stages.<sup>[59]</sup> Secondly, in the literature a distinction is made between generating and adopting an innovation.<sup>[14]</sup> Generating innovations is a creative process, which is characterised by variation, search, experimentation and discovery, and which produces new knowledge and information. Innovation adoption, on the contrary, is a problem-solving process, which is planned more tightly, and can be characterised by selection, refinement, choice and execution. In our opinion, actual implementation in the inventing organisation is not a “*conditio sine qua non*” for innovation in radiotherapy centres. The development of a new product, service, market or technology is valuable in itself, even if the innovation is not implemented in the organisation which first generated it. Indeed, the generation of innovative ideas creates the possibility to adopt the innovation elsewhere, and thus improve health care delivery in general. For this reason, we decided that the research indicators that survived the cut-off could all justifiably be included.

When considering our list of indicators, some clear innovation-generating indicators can be seen, for example, the patent indicator (indicator 3) and the research indicators on patients in clinical trials (indicators 4 and 5). All other indicators will have to be evaluated during actual measurement, with the researcher classifying a particular innovation as being of either the generating or the adoptive kind. By following such a procedure, it will be possible to measure the level of different innovation activities that can potentially cause tension in the organisation and which may constitute a hurdle for applying an innovation.

#### 4.4 Third viewpoint: degree of innovation

The third and final viewpoint concentrates on the degree of innovation, with a special focus on more radical types of innovation (as opposed to incremental innovation). Radical innovations are mostly, but not always, based on yet unused

engineering and scientific principles, and often open up new markets and potential applications. These innovations are non-linear, resulting in a discontinuation of the existing line regarding treatments, technology, markets, organisational behaviour, systems, structure and so on.<sup>[15]</sup> Incremental innovation refers to alterations to existing products, which lead to improvement in content or efficiency. The latter type of innovation is mostly linear and continuous in character.

The view on degree of innovation can help to clarify discussions about the true nature of innovation. Some people (including some respondents in our Delphi study) qualify small innovations as an improvement rather than a true innovation. In our opinion, however, improvement can be regarded as incremental innovation, although the impact and underlying conditions are different than in the case of radical innovation. Our indicators do not aim to quantify how radical an innovation is, yet when measuring innovation in practice, all innovations can be classified by categorisation in terms of our indicators: they can range from incremental or radical, depending on the basis of the definition used and the subject of measurement. For example, incremental product innovation is innovation in existing products (*e.g.* hypo-fractionation in radiotherapy, as an advancement on conventional fractionation), while radical innovation signifies the development of a completely new product (*e.g.* proton therapy).

Capturing incremental innovation is difficult, however, because generally speaking incremental innovation is a continuous process that forms part of the daily routine of employees.<sup>[30]</sup> It is therefore hard to measure all incremental innovation. Nonetheless, measurement can give an impression of the level of radical and incremental innovation which has been noted. This implies that, although we cannot get full information on the potential causes of tension, we can arrive at the best possible estimate. It is important to realise this, because the widely-held opinion is that the cumulative impact of incremental innovation might well be equivalent to - if not bigger than - the impact of radical innovation. To ignore this fact would result in a biased view.<sup>[47]</sup>

#### 4.5 Final remarks

We expect that by using these indicators of innovation in daily practice, a distinction can be made between innovation-generating and innovation-adopting activities, and between radical or incremental innovation. This can be done by comparing the innovation activities by type of innovation with the definitions concerning radical or incremental innovation and innovation generation or innovation adoption. It is important to make this distinction, because certain forms of innovation can create tension in an organisation, particularly if innovation takes place in an environment that is dominated to some

extent by efficiency goals or considerations for patient care. Such tensions can hinder successful innovation.

In addition, it should be noted that, remarkably enough, all our remaining indicators concern output measures. This implies there is no need for factors to determine the efficiency of input indicators, such as the number of research staff, because high input does not necessarily mean high output of innovation.<sup>[32]</sup>

Finally, this study has focussed on innovation indicators without addressing the data collection methods to measure the level of innovation in radiotherapy centres. In the literature, a number of shortcomings are listed of data collection in organisations by means of questionnaires.<sup>[33,48]</sup> Such data are not completely objective, as the respondent decides what exactly constitutes an innovation. Also, indicators from surveys sometimes suffer from estimated-answer bias and low response rates. This means that, to use our indicators in future studies, questionnaires are probably not the most suitable method. Instead, an approved protocol is needed, with one or two investigators systematically interviewing a specified sample of the staff in the centres involved.

#### 4.6 Limitations and further studies

There are several limitations to our study. First, although the Round 1 response rate was reasonably good “with 14 out of 21 respondents (67%) submitting indicators for innovation” the Round 2 response rate was much lower (20%). A low response rate is also seen in many studies requiring response by physicians; Willis *et al.* showed for instance that only 1/3 of the health care providers reported response rates higher than 60% in the 2005-2009 period.<sup>[60]</sup> Response rates as low as 5% to 10% are also commonly reported in health care.<sup>[61]</sup> In our case, we think that the disappointing response rate in Round 2 can be explained by the fact that most of the potential respondents were radiotherapy professionals, who are not very active in the area of management. Since we used a third round, where we asked the professors with a chair in innovation to review the results gained so far, we feel that the response rate of Round 2 is unlikely to constitute

a problem. Also, although this specific response rate was low, we still received feedback from a considerable group of professionals (n = 66). Furthermore, we only accepted indicators if consensus was reached in Round 4 between the department chairpersons: the review by the Round 2 NVRO members was just an aid for reaching consensus. For these reasons, we consider our results to be valid.

Second, in order to arrive at a workable set of indicators, we defined subjective cut-off scores for measurability and suitability. We feel comfortable with our decision, because our indicators are comparable to the indicators mentioned in the literature; nevertheless, our decision was not based on previous research, as the necessary data were not available.

Third, we performed this study in one country only (the Netherlands), which may affect the potential to generalise our results to different settings. Finally, to test the selected indicators, they need to be measured in practice. We recommend future research be done on testing the set, especially its measurability.

Having said all this, we do feel we have taken an essential first step towards developing indicators for measuring the degree and type of innovation in radiotherapy centres. It is clear that these indicators have to be validated further by measuring them in actual clinical practice. These validated indicators will then allow us to investigate the relation between innovation and its effects, and relate the degree of innovation in radiotherapy centres with organisational and work characteristics in further multi-centric studies.

## 5. CONCLUSIONS

We developed a tool for measuring the level of innovation in radiotherapy centres. This tool will be used to investigate in radiotherapy centres the relation between innovation and possible factors inhibiting or stimulating successful innovation and between the level of innovation and its effects. We expect that the resulting data will assist us in deciding how to organise our clinics to combine innovation with cost-efficient patient care.

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