RESEARCH ARTICLE

Clinical and economic benefits of the Intellispace Portal applications CT TAVI and Spectral CT: Findings from a two-step Delphi panel [version 1; peer review: 1 approved]

Mahdi Veillet-Chowdhury¹, James E. Harvey², Peter S. Wang³, Saswat Panda⁴, Mark Connolly^{4,5}, Marlene A. Mesarosh^{6,7}, Goran Medic^{id}^{5,8}, Jiwan Beth⁹, Bodo Wiegand^{id}⁹, Raman Danrad¹⁰

¹Wellspan Health System, Pennsylvania, USA

²Division of Cardiology, WellSpan York Hospital, York, Pennsylvania, USA

³Department of Radiology, Einstein Medical Center, Philadelphia, USA

⁴Global Market Access Solutions LLC, Charlotte, North Carolina, USA

⁵Department of Pharmacy, Unit of Pharmacotherapy, -Epidemiology & -Economics, University of Groningen, Groningen, 9700 AB, The Netherlands

⁶Enterprise Diagnostic Informatics, Philips, Atlanta, USA

⁷Business to Market Operations Leader for ICAP, Philips, Atlanta, USA

⁸Health Economics, Philips, Eindhoven, Noord-Brabant, 5621JG, The Netherlands

⁹Market Access, Philips, Amsterdam, Noord-Holland, 1096HS, The Netherlands

¹⁰Department of Radiology and Department of Internal Medicine (Cardiology), LSU Health Science Center and University Medical Center, New Orleans, Louisiana, USA

v1 First published: 26 Feb 2020, 9:153
<https://doi.org/10.12688/f1000research.22180.1>

Latest published: 26 Feb 2020, 9:153
<https://doi.org/10.12688/f1000research.22180.1>

Abstract

Background: IntelliSpace Portal (ISP) is an advanced visualization platform that offers a single integrated solution designed to help physicians work more efficiently. This study aimed to develop a consensus statement on the clinical and economic benefits of two IntelliSpace Portal (ISP) applications (computed tomography (CT) transcatheter aortic-valve implantation (TAVI) and Spectral CT) applications.

Methods: A modified Delphi method of two rounds of queries was used in a panel of 17 experts (11 for Spectral CT and 8 for CT TAVI). The experts were identified via referral and selected to achieve a balanced representation of subject matter experts. The Delphi process was conducted online using the MESYDEL platform. Two rounds of Delphi queries were conducted between July 22 and October 14, 2019. All data was collected prospectively.

Results: Areas of consensus represented contribution of ISP applications toward quadruple aim goals. Consensus was reached that the Spectral CT application led to more confident decision making, improved diagnosis capabilities leading to better treatment paths, and a better work experience. Panelists noted that they

Open Peer Review

Approval Status

1

version 1

26 Feb 2020

[view](#)

1. **Alan Haycox**, University of Liverpool,
Liverpool, UK

Any reports and responses or comments on the article can be found at the end of the article.

required fewer tests to make a diagnosis using Spectral CT. The majority of physicians (63%) agreed that CT TAVI led to time savings for 'device sizing' results, and 75% of physicians agreed that the tool resulted in a better work experience.

Conclusions: The increased diagnostic confidence of spectral information could eliminate the need for many follow-up scans in patients, resulting in clinical benefit to the patient in terms of reduced exposure to radiation and economic benefit to healthcare systems in reducing the number of additional scans. The staff satisfaction goal of the quadruple aim is also satisfied by Spectral CT and CT TAVI leading to a better work experience in our panelist physicians. This may result in indirect benefits such as reduced rates of physician burnout and greater provider satisfaction.

Keywords

Dual-energy CT, Spectral CT, TAVI, TAVR, IntelliSpace Portal

Corresponding author: Bodo Wiegand (Bodo.Wiegand@philips.com)

Author roles: Veillet-Chowdhury M: Writing – Review & Editing; Harvey JE: Writing – Review & Editing; Wang PS: Writing – Review & Editing; Panda S: Data Curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; Connolly M: Data Curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – Review & Editing; Mesarosh MA: Conceptualization, Funding Acquisition, Methodology, Writing – Review & Editing; Medic G: Conceptualization, Methodology, Writing – Review & Editing; Beth J: Conceptualization, Data Curation, Formal Analysis, Investigation, Project Administration, Writing – Review & Editing; Wiegand B: Conceptualization, Data Curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Project Administration, Resources, Supervision, Validation, Writing – Review & Editing; Danrad R: Writing – Review & Editing

Competing interests: MVC, JEH, PSW and RD have no conflicts of interest, they provided their opinions and scientific oversight for the whole project and did not receive any financial support. MAM, GM, JB and BW are the employees of Philips. SP and MC are the employees of Global Market Access Solutions Sàrl. Global Market Access Solutions Sàrl. received funding from Philips to perform Delphi panel and write the manuscript.

Grant information: The study was supported by funding from Philips.

The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Copyright: © 2020 Veillet-Chowdhury M *et al.* This is an open access article distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

How to cite this article: Veillet-Chowdhury M, Harvey JE, Wang PS *et al.* **Clinical and economic benefits of the Intellispace Portal applications CT TAVI and Spectral CT: Findings from a two-step Delphi panel [version 1; peer review: 1 approved]** F1000Research 2020, 9:153 <https://doi.org/10.12688/f1000research.22180.1>

First published: 26 Feb 2020, 9:153 <https://doi.org/10.12688/f1000research.22180.1>

Introduction

In recent years, healthcare spending in OECD countries has grown by an average of 1.8% in 2017—a noticeable decrease from the 3.5% growth observed in 2015 and 2016 and significantly below the rates experienced before the 2008 financial crisis (OECD, 2019a). Preliminary estimates for 2018 from the OECD point to growth having picked up to around 2.5% in 2018 (OECD, 2019a). At this rate, the rise of annual healthcare spending is above annual inflation rates (Barlas, 2019).

On average, health spending as a share of GDP was 8.8% in 2017. In the United States (U.S.) 17.1% of GDP is spent on healthcare, which is significantly more than Switzerland (12.3%) and France (11.3%), the second- and third-highest spenders (OECD, 2019a; OECD, 2019b). By comparison Turkey (4.2%), Luxembourg (5.4%) and Mexico (5.4%) were the lowest spenders in terms of percentage of GDP (OECD, 2019a; OECD, 2019b). Around 75% of health spending on average in OECD countries is paid through government or compulsory insurance arrangements (OECD, 2019a).

Because the current rising healthcare costs are unsustainable for governments in the long-run, Donald Berwick and colleagues at the Institute for Healthcare Improvement (IHI) provided a framework for the delivery of high value care in the USA—the Triple Aim. Triple Aim is centered around three overarching goals: improving the individual experience of care; improving the health of populations; and reducing the per capita cost of healthcare simultaneously (Berwick *et al.*, 2008). Health systems globally grapple with the challenge of improving the health of populations while simultaneously maintaining or lowering healthcare costs (Sikka *et al.*, 2015).

The successful achievement of the Triple Aim requires highly effective healthcare organizations. The backbone of any effective healthcare system is an engaged and productive workforce (LLI, 2013). However, the Triple Aim does not explicitly acknowledge the critical role of the workforce in healthcare transformation. This is why the ‘quadruple aim’ has become a new and important framework by adding a fourth component to the equation: improving the staff experience (Bodenheimer & Sinsky, 2014; Jeffs, 2018; Sikka *et al.*, 2015).

IntelliSpace Portal (ISP) (Philips, Amsterdam, The Netherlands) is an advanced visualization platform that offers a single integrated solution designed to help physicians work quickly, especially for complex cases and follow-up. Key features provided by ISP are the following: (1) to provide a comprehensive overview of the patient and to quantify and diagnose using multi-modality clinical applications accessed from any point of hospital’s network; (2) to provide a broad range of leading clinical applications that span multiple domains; (3) to enable a physician to focus more on patient care by creating workflow efficiencies and time-saving tools that have been shown to cut complex patient analysis time by up to 77% (Kadavigere *et al.*, 2011) and automatically adapt to the physician’s way of working (Philips, 2016b; Philips, 2018).

ISP leverages a broad range of over 80 applications, spanning clinical domains including oncology, cardiovascular, neurology, pulmonology and others. These applications offer exceptional flexibility to access, analyze, and quantify patient data in one unified view (Philips, 2016b; Philips, 2018). Under the rubric of quadruple aim in healthcare, we explore the clinical and economic benefits of two selected ISP applications: computerized tomography (CT) transcatheter aortic valve implantation (TAVI) and spectral CT.

CT TAVI is a non-invasive post-processing application that provides semi-automatic measurements of the aorta and aortic valve that are necessary for effective pre-TAVI planning. Specifically, the software provides model-based segmentation of the aortic valve, ascending aorta, and left ventricle with automatic calcium segmentation, improved landmark detection, and semi-automated detection of the coronary ostia. In addition, it provides semi-automated detection and dimensions measurements of the aortic annulus, left ventricular outflow tract, sinotubular junction, sinus of valsalva, ascending aorta and distance to coronary ostia for TAVI-device sizing. It also predicts an accurate starting angle of the C-arm for device deployment in the catheterization laboratory or hybrid operating room. Lastly, it can provide a semi-automated assessment of iliofemoral and subclavian vascular access, thus enabling additional potential time savings (Philips, 2016b; Philips, 2018).

The ISP suite of Spectral CT applications has been optimized for the viewing and analysis of spectral data sets from the IQon Spectral CT scanner (Philips, Amsterdam, The Netherlands). Physicians can access the desired applications on the virtual desktop via thin client from anywhere in the hospital and also from outside the hospital via a secured network connection. The tools help radiologists improve tissue differentiation, quantify iodine concentration, and support diagnoses. The clinical benefits of spectral applications include: (1) Enhancement of the conventional image by overlaying an iodine map; (2) Determining the presence or absence of enhancement via virtual non-contrast images; (3) Visualization of images at different energy levels (40–200 keV); (4) ease of switching between various spectral results through a viewport control; (5) the ability to manage and create user/site-specific presets; (6) the ability to characterize a lesion using scatter plots; and (7) Tissue characterization using attenuation curves. The biggest economic benefits are offered by reduction of follow-up exams (Philips, 2016a; Prabhakar *et al.*, 2018).

The objective of this research is to use an online Delphi survey framework to gather information on real world use and develop a consensus statement on the clinical and economic attributes of two ISP applications: CT TAVI and Spectral CT.

Methods

Background

The Delphi method is a structured forecasting/decision-making tool that has been successfully applied to health research in

many disciplines (Balabanova *et al.*, 2011; Booth *et al.*, 2011). The Delphi method creates conditions that are favorable to a convergence of opinions, while at the same time allowing moderators to clearly discern points of dissent. It usually takes the form of a written questionnaire and allows for anonymous and independent consultation and argumentation, thereby avoiding some of the drawbacks of face-to-face confrontations on both the social level (e.g. power relations within a group) and the practical level (time consuming, especially with geographically dispersed individuals, which is also applicable to our case) (Duin, 2016). Responses are only visible to the moderator(s) and not to the participants in order to avoid self-moderation bias. The iterative nature of the consultation builds on the feedback of the respondents. This allows for the correction of potential bias in the initial questions which is the main fragility of classical (non-iterative and non-interactive) queries. A potential problem with the Delphi method is the creation of a bottleneck towards convergence of opinions during the process (Linstone & Turoff, 2002; van der Gracht, 2012). It is therefore important to use both open and closed questions, and to take into consideration the whole spectrum of opinions. The online platform used in our study provides additional advantages such as low respondent drop-out rates (reducing effects of self-selection) and the possibility for respondents to revisit, complement or modify their answers during both rounds (generating more data) (Francois *et al.*, 2011).

Recruitment

Expert users of Philips ISP - CT TAVI and Spectral CT were identified via referral by Philips clinical workflow specialists and selected to achieve a balanced representation of these expert users from different regions within the US. Experts were recruited via email. All experts declared all conflicts of interest before participating in the panel. Throughout the Delphi, respondents were encouraged to explain their choice for closed-ended and multiple-choice questions. All questions are available as part of the *Underlying data* (Wiegand, 2020a).

The Delphi process was conducted online using the MESYDEL platform (Mesydel, 2019) developed by the Spiral Research Center at the University of Liège (Belgium); however, it could readily be performed manually. Two rounds of Delphi queries were launched and analyzed between July 22 and October 14, 2019. The project organizers designed questions on the survey. A duration of six weeks for Round 1 and five weeks for Round 2 were given to panelists to respond to the surveys. Reminder emails were circulated for each iteration.

The second round mainly focused on ambiguities or disagreement in the first round, clarifying areas of disagreement, and fostering more consensus on approaching the issue differently according to the participants' input. This was achieved by providing the survey responses from Round 1 to the panelist during Round 2 in which clarification or consensus was sought.

Data analysis

Quantitative data for closed questions was tabulated using MESYDEL, an online Delphi panel platform, and Microsoft

Excel 365. The responses to the first round of questioning informed the design of the second round of questions, thus allowing for questions to be modified as needed. Particular attention was paid to areas of disagreement. Additionally, questions were reviewed with the survey group based on key observations from round 1 of the survey. All data was collected prospectively and analyzed using Microsoft Excel to obtain descriptive and summary statistics.

Demographics and response rate

The Delphi panel consisted solely of U.S.-based experts. A response rate of 73% was achieved with 11 radiologists responding to the Spectral CT portion of the survey and 80% for the CT TAVI portion of the survey with 8 physicians responding. Of the Spectral CT survey participants, 91% had over 10 years of experience and 55% had over 20 years of experience (Table 1). Of the participants in the TAVI survey, 87% had over 10 years of experience, and 50% had over 20 years of experience (Table 2).

Ethical issues

The results described here were derived using the Delphi Panel approach which is based on expert opinion. No patients have been used for this study and no patient data is collected and no patient samples or results have been used. No individual can be identified from the results presented. No animals have

Table 1. Radiologist demographics, results from spectral computed tomography (CT) survey (n = 11).

Characteristic	Number	Percent
Radiologist demographics		
Years of experience		
<10	1	9%
10–19	4	36%
≥20	6	55%
Gender		
Male	10	90%
Female	1	9%
Affiliation with an academic center		
Yes	9	82%
No	2	18%
Usage related questions		
How often do you use the ISP?		
Daily	6	54%
Monthly	5	46%
How often do you use the Spectral CT tool?		
Daily	8	73%
Monthly	3	27%

ISP, IntelliSpace Portal.

Table 2. Physician demographics, results from the transcatheter aortic valve implantation survey (n = 8).

Characteristic	Number	Percent
Radiologist demographics		
Years of experience		
<10	1	13%
10–19	3	37%
≥20	6	50%
Gender		
Male	7	87%
Female	1	13%
Affiliation with an academic center		
Yes	4	50%
No	4	50%
Usage related questions		
How often do you use the ISP?		
Daily	7	87%
Monthly	1	13%

ISP, IntelliSpace Portal.

been used in this study. All participants provided written informed consent to participate.

Results

Responses to each question from each participant are available as *Underlying data* (Wiegand, 2020a).

Spectral CT

The sentiment toward the Spectral CT tool within the ISP was very positive, with 90% of the respondents agreeing (hereafter, “agreeing” refers to “somewhat agree” or “completely agree” responses to the Likert-style questions) that it clinically benefits their everyday work (Figure 1). The respondents qualified their answers with comments and three respondents noted the virtual non-contrast (VNC) test feature as the most relevant feature. In addition, three respondents commented that Spectral CT improves their diagnostic confidence (*Underlying data*, Question 4; Wiegand, 2020a). In a question to assess whether the Spectral CT tool has led to more confident decision-making, 100% of respondents agreed with this statement. One respondent stated that the confidence in decision-making is, “...a result of additional precious information in [the] form of Spectral Detector CT reconstruction, [which is] useful in many situations like evaluating indeterminate cysts and incidentalomas that are routinely encountered.” Other respondents indicated that they valued the VNC feature for use in stroke

Figure 1. Responses to general Likert-style questions for Spectral CT and CT TAVI surveys. Questions were asked in a Likert-form, e.g., statements were preceded by: “Please state to what extent you agree with the following statement:”. The comparator to Spectral CT is not having Spectral CT or ISP. For Spectral CT questions, n = 11, for CT TAVI questions, n = 8. CT: computed tomography; TAVI: transcatheter aortic-valve implantation.

patients and that they use the additional image types to confirm diagnoses (*Underlying data*, Question 12; [Wiegand, 2020a](#)).

All participants agreed that the Spectral CT application has led to improved diagnostic capabilities, leading to better treatment paths for patients (*Underlying data*, Question 10; [Wiegand, 2020a](#)). They state that it helps them with certain types of patients such as stroke patients and those with pulmonary emboli and that the additional imaging lends to more confidence in diagnosing. This confidence is highlighted in an open-ended question, “*What elements of Spectral CT do you feel lead to a better patient experience?*” (*Underlying data*, Question 36; [Wiegand, 2020a](#)), where doctors elaborated on how confidence in diagnosis impacts patients. One doctor wrote: “*Patients may not directly experience this but when a radiologist hedges it significantly changes the arc of their care. On the other hand, when a radiologist is more confident, then the clinician is also more confident putting the patient on anticoagulation.*”

In a question to gauge the effect of the Spectral CT application on the work experience (*Underlying data*, Question 9; [Wiegand, 2020a](#)), 91% of doctors agreed that the application improved their work experience. Two doctors further qualified their statements by reiterating that diagnostic confidence is improved. Another doctor elaborated further and stated that, “*with [Spectral CT] and its reconstructions we are now telling the complete story of the disease rather than just providing the snapshot with conventional CT. For me this leads to a pleasant and better work experience.*” In Round 2 in a follow up question to delve deeper into the technologies impact on the work experience, we explored further for those participants that agreed in Round 1. Responses ranged from specific tools provided in the Spectral CT application such as, “*better visualization of enhancement by low keV images and iodine mapping*”, and the option to always have a retrospective picture archiving and communication system (PACS), as well as the virtual desktop link to easily collaboratively review and analyze data. They also note the benefit of being able to bookmark and share certain data amongst the clinical team. Another doctor gave a similar comment, but also noted that they believe that the tool may prevent additional follow up exams by allowing them to make a confident diagnosis. Panelists also mention that an improved work experience may help them counter provider burnout (*Underlying data*, Question 26; [Wiegand, 2020a](#)).

We also asked the panelists questions on the potential of Spectral CT to reduce the number of scans needed for diagnosis, “In Round 1 of the Delphi Panel a participating expert highlighted the following, please state to what extent you agree with the following statement: *Spectral CT has helped improve on accuracy and confidence of diagnosis (compared to not having Spectral CT & ISP), leading to less frequent follow-ups and repeat exams.*” (*Underlying data*, Question 33; [Wiegand, 2020a](#)). In total, 27% of respondents somewhat agreed, and 56% completely agreed, while 18% of them completely disagreed with this statement. The experts who did agree feel it resulted in time-savings gave estimates ranging from 15 minutes per scan, 30–60 minutes per day, and 40–50% time reduction.

While the rest of the respondents to the open question asking for comment replied that they did not have an accurate sense of how much time was saved.

CT TAVI

The CT TAVI application of the ISP was thought to yield time-savings in ‘device sizing’ related tests. A question based on this was asked to the experts and 85% agreed that it did reduce time-savings, while 15% responded “neutral” (*Underlying data*, Question 66; [Wiegand, 2020a](#)). There was a lack of responses to the open-answer portion of this question, but one piece of critical feedback was that “*while the software may reduce work, the time for analysis is roughly the same*”. Another respondent answered that “*CT TAVI produces multiple measurements quickly with a small amount of user input.*” In a follow-up question (*Underlying data*, Question 67; [Wiegand, 2020a](#)) under this topic, we asked for numerical estimates of time-savings. Only five of the respondents responded to this question, but of the four responses which were given in time units “per case”, they estimated that approximately 13.1 minutes are saved per case. One respondent estimated that they saved “*1 to 2 hours per week*”.

We also asked whether CT TAVI decreases one’s cognitive load due to automation in location selection within the tool (*Underlying data*, Question 69; [Wiegand, 2020a](#)) whereby 100% of the respondents agreed that it did reduce cognitive load. However, in the comments one expert qualified that, “*the software reduces some of the workload, [but] the user still needs to check for errors, which are uncommon with the annular sizing tool, but common with the vascular analysis tool.*” A further two experts noted that when the quality of the CT scan is good, annulus points and automated landmarks are accurate.

Quadruple aim

Questions pertaining to quadruple aim goals were presented to all participants in Round 1 of the survey. Some participants also received follow-up questions where clarification was needed in Round 2. Responses to these questions are summarized in [Figure 2](#) for the Spectral CT portion of the survey and in [Figure 3](#) for the CT TAVI portion of the survey.

Discussion

This study aimed to identify potential benefits of an advanced visualization platform, ISP, and its two applications: Spectral CT and CT TAVI. Areas of consensus represent the contributions of ISP towards the pillars of the quadruple aim methodology: improving the health of populations, enhancing the experience of care for individuals, reducing the per capita cost of health care, and higher levels of staff satisfaction. Consensus was reached that the Spectral CT application led to more confident decision making and a better work experience. While a consensus was not achieved for many points of the CT TAVI portion of the survey, there was a positive trend in the responses suggesting that the technology is beneficial and that it improves the work experience and effectiveness of patient treatment. The benefits of reproducible and accurate automated aortic

Figure 2. Responses to quadruple aim questions pertaining to spectral computed tomography (CT) (n = 11). **This question only had 9 responses; Questions were asked in a Likert-form, and "Please state to what extent you agree with the following statement: The Spectral CT application has led to (compared to not having Spectral CT and IntelliSpace Portal (ISP)):" preceded each statement.

Figure 3. Quadruple aim question responses to computed tomography (CT) transcatheter aortic-valve implantation (TAVI) questions (n = 8). Questions were asked in a Likert-form, and "Please state to what extent you agree with the following statement: The CT TAVI application has led to (compared to not having CT TAVI and IntelliSpace Portal (ISP)):" preceded each statement.

annulus sizing and related TAVI planning measurements is potentially invaluable as TAVI planning is a multidisciplinary approach which allows subspecialists and vendors to make decisions on validated data.

Patient experience

We achieved consensus to the question on Spectral CT leading to improved diagnosis capabilities leading to better treatment paths for patients (*Underlying data*, Question 36; [Wiegand, 2020a](#)). A radiologist commented that confidence on their part leads to confidence on the clinician's part on choosing therapies for the patient. This is done without hedging and thus removes the need for additional tests to give a diagnosis. Another doctor also noted that the ability to retrospectively perform spectral analysis on every patient is crucial because it removes the need to prospectively determine if a study requires spectral or dual energy analysis. They note, "*the ability to perform the spectral analysis without a significant cost of additional radiation to the patient is also highly beneficial.*" A key benefit of Spectral CT is this ability to retrospectively use data to create virtual unenhanced images and enhanced material density maps to glean more from a single scan ([Massat, 2018](#)). Because Spectral CT is a dose-neutral exam compared to conventional CT, the non-contrast phase of some protocols is eliminated and the need for additional exams is reduced ([Massat, 2018](#)). Spectral CT simultaneously uses two different energy settings, which allows differentiation of materials based on material density. Radiologists can use this feature of Spectral CT to acquire virtual unenhanced images as well as iodinated contrast material-enhanced material density images from a single scan ([Silva et al., 2011](#)). These features of Spectral CT improve patient care by minimizing their exposure to radiation dose from scans while also giving radiologists access to additional images to inform a diagnosis.

Reduction of scans

Diagnostic imaging costs and use have increased dramatically over time. It was reported that CT use increased from 52 per 1000 enrollees in 1996 to 149 per 1000 in 2010 ([Smith-Bindman et al., 2012](#)). Additionally, approximately 20% to 50% of tests fail to provide information that improves clinical care ([Neeman et al., 2012](#)). Amidst burgeoning healthcare spending, it is imperative to investigate new technologies and interventions for reducing excessive tests. A key finding of our survey was that panelists felt that the use of Spectral CT improved their confidence in making a diagnosis. Additionally, they felt that they required fewer tests to make a diagnosis. We found that most doctors did not have an accurate sense of exactly how much time is saved from the implementation of image portals and the use of additional scans from Spectral CT (*Underlying data*, Question 33; [Wiegand, 2020a](#)). Availability of spectral information could eliminate the need for follow-up scanning in patients with sub-optimal exams and incidental findings, increasing the diagnostic confidence of radiologists and resulting in a potential annual savings of \$55,000 or higher depending on the practice and number of exams ([Prabhakar et al., 2018](#)).

Time savings

Parts of our survey were designed to measure the perceived amount of time-savings from the use of the ISP tool and Spectral CT. However, we found that most of the respondents did not have an accurate sense for how much time is saved. Some radiologists estimated time-savings of 30–60 minutes a day while others estimated 15 minutes per scan was saved. Other respondents noted that elimination of follow up procedures does not shorten their workflow and that more time is needed to process spectral data. These results show that the benefits of Spectral CT would be highly dependent on the exact practice and type of caseload of a radiologist.

Of the eight physicians responding to the TAVI survey, five stated that they believed the tool lead to time savings when used for 'device sizing' results. Four of them gave their response in "per case" savings, giving a mean time savings of 13 minutes per case. The last doctor estimated a time savings of one to two hours per week from using the tool. Reducing time needed to conduct tests is crucial in improving radiologist throughput. Throughput of patients is complex and relies on many factors including patient availability, acuity, triage, and other activity ([Levenson et al., 2012](#)). Time-savings when reading any type of test can prove to be beneficial in improving throughput and volume of a practice.

Staff satisfaction

The fourth aim of the IHI pertaining to staff satisfaction or "joy in work" was added because studies have shown that parameters such as physician burnout lead to lower patient satisfaction and even poorer patient outcomes ([Halbesleben & Rathert, 2008](#)). In a systematic review, researchers identified 21 of 30 studies that measured burnout found a significant association between burnout and patient safety, whilst a further four studies also found a connection to patient safety ([Hall et al., 2016](#)). Thus, an important result of our survey was that 91% of respondents agreed that the spectral CT application makes their work experience better. Doctors who gave comment also unanimously agreed that the remote work capabilities of ISP are very convenient and benefits them in sharing data and in continuity of work (*Underlying data*, Question 2; [Wiegand, 2020a](#)). They also noted that the technology enabled them to assist colleagues from home while providing second opinions for emergent cases through the virtual portal. Even a marginal increase in satisfaction amongst radiologists is significant as it would play some role in preventing burnout and dissatisfaction with work, which could potentially result in improving patient satisfaction, outcomes, and safety.

Conclusions

An expert panel found the Spectral CT and CT TAVI applications of the Intellispace Portal to be positive regarding many of the healthcare quality improvement goals outlined in the Quadruple aim framework. The panelists agreed that more confident diagnosis can be made with fewer scans and that they enjoyed using Spectral CT as a part of their practice. Further study utilizing real world experience is needed to determine

potential economic and physician satisfaction benefits of these new tools in radiology.

Data availability Underlying data

Figshare: Extended data - Delphi Questions v1.0. <https://doi.org/10.6084/m9.figshare.11734353.v1> (Wiegand, 2020a).

This project contains all questionnaires with all answers given by Delphi panel participants.

Figshare: Extended Data - Delphi Panel ISP. <https://doi.org/10.6084/m9.figshare.11778486.v1> (Wiegand, 2020b).

This project contains the multiple choice questions data used to generate Figure 1–Figure 3.

Data are available under the terms of the [Creative Commons Zero “No rights reserved” data waiver](#) (CC0 1.0 Public domain dedication).

Acknowledgements

We would like to thank the following members of the Philips ICAP team whose efforts facilitated the success of this document.

- 1) Greg Woodward, Sr. Mgr. IntelliSpace Portal Implementation and Clinical Adoption
- 2) Diane Gressley, Clinical Workflow Adoption Consultant, Project Lead
- 3) Clinical Workflow Adoption Consultants; Evelyn Roehr, Diana Wisler, Robert Verity, Ryan Gunter

Disclaimer

Dr. Raman Danrad:

- I. Speaker Bureau of Philips
- II. The contribution to article is personal opinion of the author and does not represent endorsement by LSUHSC and UMC- New Orleans, Louisiana USA.

References

- Balabanova Y, Gilsdorf A, Buda S, *et al.*: **Communicable diseases prioritized for surveillance and epidemiological research: results of a standardized prioritization procedure in Germany, 2011.** *PLoS One*. 2011; 6(10): e25691. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Barlas S: **Are Hospital Prices a Bigger Problem than Drug Prices?: Congress Doesn't Know, Doesn't Care.** *P T*. 2019; 44(5): 259–299. [PubMed Abstract](#) | [Free Full Text](#)
- Berwick DM, Nolan TW, Whittington J: **The triple aim: care, health, and cost.** *Health Aff (Millwood)*. 2008; 27(3): 759–769. [PubMed Abstract](#) | [Publisher Full Text](#)
- Bodenheimer T, Sinsky C: **From triple to quadruple aim: care of the patient requires care of the provider.** *Ann Fam Med*. 2014; 12(6): 573–576. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Booth A, Clarke M, Ghersi D, *et al.*: **Establishing a minimum dataset for prospective registration of systematic reviews: an international consultation.** *PLoS One*. 2011; 6(11): e27319. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Duin P: **Foresight in organizations: methods and tools.** New York, NY: Routledge; 2016. [Publisher Full Text](#)
- Francois A, Rieppi S, Thiry A: **Démarches participatives et approches quali-quantitatives: le logiciel Mesydel. La participation en action.** Bern: Peter Lang. 2011. [Reference Source](#)
- Halbesleben JR, Rathert C: **Linking physician burnout and patient outcomes: exploring the dyadic relationship between physicians and patients.** *Health Care Manage Rev*. 2008; 33(1): 29–39. [PubMed Abstract](#) | [Publisher Full Text](#)
- Hall LH, Johnson J, Watt I, *et al.*: **Healthcare Staff Wellbeing, Burnout, and Patient Safety: A Systematic Review.** *PLoS One*. 2016; 11(7): e0159015. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- Jeffs L: **Achieving the Quadruple Aim in Healthcare: The Essential Role of Authentic, Complex and Resilient Nurse Leaders.** *Nurs Leadersh (Tor Ont)*. 2018; 31(2): 8–19. [PubMed Abstract](#) | [Publisher Full Text](#)
- Kadavigere R, Maiya M, Rao V, *et al.*: **Standardized Results of CT Angiography Obtained with Automated Postprocessing Using a Dedicated Server: A Workflow Optimization Study.** A collaboration of Philips Healthcare and Kasturba Medical College at Manipal University, India. *RSNA 2011 Scientific Assembly and Annual Meeting, November 26 - December 2, 2011, Chicago IL*. 2011. [Reference Source](#)
- Levenson RB, Camacho MA, Horn E, *et al.*: **Eliminating routine oral contrast use for CT in the emergency department: impact on patient throughput and diagnosis.** *Emerg Radiol*. 2012; 19(6): 513–517. [PubMed Abstract](#) | [Publisher Full Text](#)
- Linstone H, Turoff M: **The Delphi method: techniques and applications.** Boston, MA: Addison-Wesley. 2002. [Reference Source](#)
- LLI: Lucian Leape Institute: **Through the eyes of the workforce: creating joy, meaning and safer health care.** Boston, MA: National Patient Safety Foundation. 2013. [Reference Source](#)
- Massat MB: **Spectral energy is redefining CT imaging.** *Appl Radiol*. 2018; 47(7): 28–33. [Reference Source](#)
- Mesydel: **Mesydel - Better Decisions Through Collective Intelligence.** 2019; Accessed 15 July 2019. [Reference Source](#)
- Neeman N, Quinn K, Soni K, *et al.*: **Reducing radiology use on an inpatient medical service: choosing wisely.** *Arch Intern Med*. 2012; 172(20): 1606–1608. [PubMed Abstract](#) | [Publisher Full Text](#)
- OECD: **Health expenditure.** 2019a; [Accessed 19th July 2019]. [Reference Source](#)
- OECD: **OECD Health Statistics 2019.** 2019b; [Accessed 19th July 2019]. [Reference Source](#)
- Philips: **Certainty lives in layers - Philips IQon Spectral CT.** 2016a. [Reference Source](#)
- Philips: **IntelliSpace Portal 9.0 - Clinical Datasheet.** 2016b.
- Philips: **IntelliSpace Portal 10 - Clinical datasheet.** 2018.
- Prabhakar R, Rong R, Martinez-Rios C, *et al.*: **Economic benefits offered by reduction of follow-up exams using spectral detector CT (SDCT).** 2018.
- Sikka R, Morath JM, Leape L: **The Quadruple Aim: care, health, cost and meaning in work.** *BMJ Qual Saf*. 2015; 24(10): 608–610. [PubMed Abstract](#) | [Publisher Full Text](#)
- Silva AC, Morse BG, Hara AK, *et al.*: **Dual-energy (spectral) CT: applications in abdominal imaging.** *RadioGraphics*. 2011; 31(4): 1031–1046. [PubMed Abstract](#) | [Publisher Full Text](#)
- Smith-Bindman R, Miglioretti DL, Johnson E, *et al.*: **Use of diagnostic imaging studies and associated radiation exposure for patients enrolled in large integrated health care systems, 1996–2010.** *JAMA*. 2012; 307(22): 2400–2409. [PubMed Abstract](#) | [Publisher Full Text](#) | [Free Full Text](#)
- van der Gracht H: **Consensus measurement in Delphi studies Review and implications for future quality assurance.** *Tech Forecasting Soc Chang*. 2012; 79(8): 1525–1536. [Publisher Full Text](#)
- Wiegand B: **Extended data - Delphi Questions v1.0.** *figshare*. Dataset. 2020a. <http://www.doi.org/10.6084/m9.figshare.11734353.v1>
- Wiegand B: **Extended Data - Delphi Panel ISP.** *figshare*. Dataset. 2020b. <http://www.doi.org/10.6084/m9.figshare.11778486.v1>

Open Peer Review

Current Peer Review Status:

Version 1

Reviewer Report 16 September 2021

<https://doi.org/10.5256/f1000research.24465.r93130>

© 2021 Haycox A. This is an open access peer review report distributed under the terms of the [Creative Commons Attribution License](#), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Alan Haycox

University of Liverpool Management School, University of Liverpool, Liverpool, UK

I very much enjoyed reading the paper and feels that it adds significantly to the literature in this area. However to be of value as a scientific approach Delphi exercises need to be subject to the same rigour as any other area of research. It is general good practice to be transparent and to describe the methodology applied fully so that the results can be assessed in light of these factors. In this regard I would have welcomed additional information on two elements of the study firstly the selection of experts who participated in the study and secondly the definition of 'consensus' and what steps if any were taken to explore dissenting views of participants. How representative were participants of the general population of clinicians who use ISP applications and exactly how did they ensure that an appropriate diversity of views were exhibited by the chosen experts? It would be helpful if the selection criteria could be outlined in the paper. Obviously the participants must have experience and expertise in the use of these techniques (the study wants to identify a correct answer rather than a unanimously agreed incorrect answer!) but within these constraints many clinicians would have met these criteria so how were participants actually chosen?

Identifying a definition of consensus in advance of a study's execution also enables the research to better identify dissent with outliers encouraged to put forward reasons for their opinion just in case the outlier actually proves to be correct or whether disagreements have been caused by a different interpretation of the questions and issues being addressed.

However in general my concerns about the application of the Delphi technique are limited by the context and purposes underlying the study, the reasons for carrying it out and the purpose to which it is being put. The aim was to assess the potential benefits of ISP and its two applications in the context of the quadruple aim framework and in this aim I believe that it has generated a great deal of valuable data. I do however agree with the conclusion to the study that further study using real world data is warranted and needed to more fully address the benefits arising from these new radiological tools.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: I am a recently retired Reader in health economics at the University of Liverpool Management School.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias
- You can publish traditional articles, null/negative results, case reports, data notes and more
- The peer review process is transparent and collaborative
- Your article is indexed in PubMed after passing peer review
- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com

F1000Research