


# BMJ Open Cost measurement in value-based healthcare: a systematic review

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## ABSTRACT

**Objective** Although value-based healthcare (VBHC) views accurate cost information to be crucial in the pursuit of value, little is known about how the costs of care should be measured. The aim of this review is to identify how costs are currently measured in VBHC, and which cost measurement methods can facilitate VBHC or value-based decision making.

**Design** Two reviewers systematically search the PubMed/MEDLINE, Embase, EBSCOhost and Web of Science databases for publications up to 1 January 2022 and follow Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines to identify relevant studies for further analysis.

**Eligibility criteria** Studies should measure the costs of an intervention, treatment or care path and label the study as 'value based'. An inductive qualitative approach was used to identify studies that adopted management accounting techniques to identify if or how cost information facilitated VBHC by aiding decision-making.

**Results** We identified 1930 studies, of which 215 measured costs in a VBHC setting. Half of these studies measured hospital costs (110, 51.2%) and the rest relied on reimbursement amounts. Sophisticated costing methods that allocate both direct and indirect costs to care paths were seen as able to provide valuable managerial information by facilitating care path adjustments (39), benchmarking (38), the identification of cost drivers (47) and the measurement of total costs or cost savings (26). We found three best practices that were key to success in cost measurement: process mapping (33), expert input (17) and observations (24).

**Conclusions** Cost information can facilitate VBHC. Time-driven activity-based costing (TDABC) is viewed as the best method although its ability to inform decision-making depends on how it is implemented. While costing short, or partial, care paths and surgical episodes produces accurate cost information, it provides only limited decision-making information. Practitioners are advised to focus on costing full care cycles and to consider both direct and indirect costs through TDABC.

## INTRODUCTION

To make sound value-based decisions in healthcare, hospital practitioners and healthcare providers require patient-level information on the costs incurred and outcomes achieved in hospitals and other healthcare organisations.<sup>1</sup> This will enable care providers to steer towards better patient-reported

## STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Using two independent reviewers, this systematic review analyses all value-based healthcare studies that have to date measured costs to provide a comprehensive comparison of cost measurement methods.
- ⇒ This research operationalises the benefits of cost measurement to practitioners by identifying four mechanisms through which cost information facilitates value-based healthcare.
- ⇒ By comparing the methods used in literature to collect cost information, this study identifies three best practices for practitioners and researchers.
- ⇒ By limiting the search to studies labelled as 'value based' in their title or abstract, this review overlooks studies that measure healthcare costs but do not explicitly relate this to value-based healthcare.
- ⇒ The included studies may have achieved value-based healthcare without reporting this explicitly, and therefore, may be overlooked when answering Research Question 2.

outcome measures, better patient-reported experience measures and clinical outcomes at equal or lower cost.<sup>2</sup> With detailed cost and outcome information, care paths can be continuously optimised.<sup>3</sup> Consequently, value-based healthcare (VBHC) is considered one solution to the financial pressures our global healthcare system places on managers and administrators<sup>1 4 5</sup> based on its promise to streamline care by focusing on desirable outcomes. In addition, hospitals can benefit from cost information by gaining insight into the sources of costs that can then guide cost-containment strategies. Therefore, cost information may facilitate process and quality improvement initiatives pursued by management.<sup>6–10</sup> Furthermore, insight into patient-level or treatment-level costs enables hospitals to negotiate appropriate prices with insurance firms, especially given the trend towards new payment models and away from fee-for-service payments.<sup>11 12</sup> Finally, it is suggested that such treatment-level cost information enables market-based competition among hospitals based on outcomes and prices.<sup>13</sup>

Considerable research has addressed the outcome side of Porter's value equation.<sup>14</sup> This value equation suggests that healthcare should pursue 'value', where value is defined as desirable and relevant patient level outcomes divided by the costs of delivering care.<sup>12</sup> Many studies have measured patient-level outcomes from both the patient perspective (eg, patient-reported outcome measures, patient-reported experience measures) and clinical outcome perspective.<sup>15 16</sup> Less is known about the cost side of this equation. Often, the term 'cost' is conflated with the price paid by insurance firms or patients to the hospital.<sup>17 18</sup> However, prices do not reflect the costs incurred by hospitals.<sup>6 19-21</sup> Prices paid by insurance firms are negotiated sums that include profit margins for both the insurer and the hospital.<sup>22</sup> They are also impacted by political factors, such as the hospital-payor mix<sup>23</sup> that refers to the range of private and public insurance schemes that make up the hospital's income stream. Finally, fee-for-service payments fail to account for patient-level differences in required care. Therefore, reimbursements are considered a poor indicator of costs.

Some authors argue for time-driven activity-based costing (TDABC) as the 'gold standard' of cost measurement in healthcare organisations.<sup>3 5 15</sup> TDABC, in a fine-grained way, matches direct and indirect costs to activities based on the time an activity takes. A care path is made up of many activities, each generating costs. The costs of a care path can thus be calculated by first identifying all costs relevant to each activity, and then summing these costs across the activities.<sup>22</sup>

Although the research is growing and results are promising, there is relatively little empirical evidence to support TDABC being the best costing method to enable VBHC since studies rarely compare methods, and often simply use whichever system the investigated hospital or care provider uses. Costing methods differ by how they allocate indirect costs to products or services.<sup>24</sup> Moreover, indirect costs cannot causally be attributed to patients, and therefore, need to be appropriately allocated. An example of such indirect costs are the salaries of administrative personnel such as the front office staff who welcome patients, coordinate schedules and manage equipment. While some costing methods ignore this (eg, direct costing), other methods average indirect costs across days or months, or systematically allocate them to patients. These methods range from imprecise to fine-grained, with TDABC towards the fine-grained end of the scale. This insight is particularly relevant to healthcare since indirect costs are high. The most fine-grained method is known as activity-based costing (ABC) and allocates indirect costs based on actual units of resources used per activity. In comparison, TDABC allocates indirect costs based on a per-minute cost, making it considerably easier to implement. Costing methods that ignore the indirect costs of a care path underestimate the true costs of the care delivered.

Previous systematic reviews have found that TDABC was able to facilitate VBHC, often highlighting cost

savings as a result but without comparing it to alternative methods.<sup>3 4 15</sup> Therefore, we do not know how TDABC compares to other cost measurement methods currently in use. While TDABC may be able to facilitate VBHC,<sup>5 15</sup> it is unclear how its benefits compare to other costing methods. For these reasons, the cost side of the value equation remains unclear. To address this challenge, we pose two research questions:

RQ1: Which costing methods are currently being used by practitioners to facilitate VBHC?

RQ2: What are the consequences of applying a specific costing method in VBHC? These consequences may include whether the method enables a cost reduction with equal or better health outcomes or provides sufficient information to further improve a care path.

This comprehensive review draws on management accounting literature to categorise costing methods reported in empirical VBHC literature published over the last two decades (1 January 2003 to 1 January, 2022) into cost measurement methods defined in the literature,<sup>24</sup> such as direct costing and absorption costing. Compiling studies in this way revealed four ways through which cost information facilitates VBHC and three best practices.

## MATERIALS AND METHODS

### Literature search strategy

To identify relevant studies, we systematically searched four major databases: Embase, Medline, Web of Science and CINAHL EBSCOhost. Our search string (online supplemental appendix) was developed by assessing previously identified relevant papers and was designed to catch all studies that address VBHC and measure the costs of an intervention, care path or treatment by including the following specific terms:

\*cost\*, microcost\*, macrocost\* AND [meaning in combination with] value-based, value based, OR valuebased

Initial search string testing showed that restricting the search to the phrase "value-based healthcare" excluded too many relevant studies because authors use phrases such as "value-based perspective" or "value-based equation" when referring to VBHC. Conversely, the term "value" was too broad and yielded more than 40 000 mostly non-specific results. By using wildcard terms indicated by stars we included many variations on the term 'cost'.

### Eligibility criteria, record selection and data collection

We limited ourselves to peer-reviewed empirical research that measured or estimated costs in a VBHC context. All the inclusion criteria and variables extracted are detailed in online supplemental appendix. The following variables, inspired by Porter<sup>2</sup> and the cost measurement methods defined in the accounting literature, were noted:

- ▶ Cost types included (direct vs indirect).
- ▶ Cost perspective (provider, payer, patient).
- ▶ Portion of the care path costed (full, partial).

- ▶ Cost measurement method used (as labelled by authors, verbatim).
- ▶ Cost measurement categories based on accounting definitions, for example, direct costing, absorption costing, step-down allocation and other recognised methods.<sup>24</sup>
- ▶ Consequences of the costing information generated.

### Patient and public involvement

This study did not involve patients or the public in designing, executing or reporting the research.

## RESULTS

### Record selection

Our four-person (ML, PP, HvE and KA) research group identified 3275 relevant papers, of which 1930 remained after removal of duplicates. We conducted a trial screening of 30 papers to test and further specify screening criteria. The screening process comprised two rounds, as shown in figure 1. In round 1, ML and PP screened the titles and abstracts independently. When there was uncertainty about the eligibility of a paper, it was retained for full-text screening following Bramer.<sup>25</sup> We accepted 674 studies based on titles and abstracts, with a Cohen's kappa inter-rater reliability score of 0.78, indicating substantial agreement.<sup>26</sup>

In round 2, both ML and PP screened the full text of all 674 studies independently. Of these, 215 studies were seen as relevant for RQ1, with a Cohen's kappa of 0.76 between ML and PP. HvE was included in any resolution discussions needed. Finally, we assessed whether each paper discussed if or how the costing information facilitated VBHC (RQ2), yielding 49 instances where the costing method facilitated VBHC. This review was not registered.

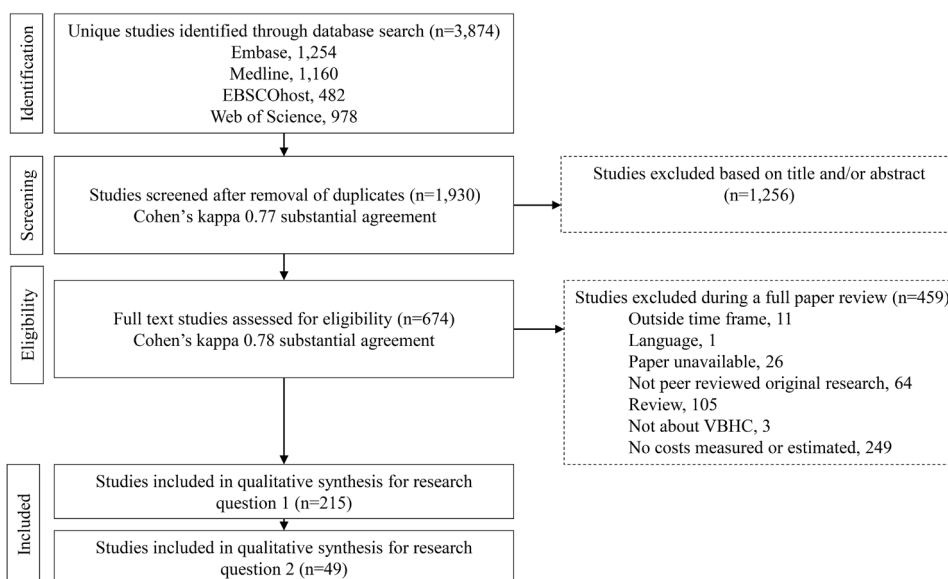
### Descriptive characteristics

An overview of the included studies is provided in table 1. Our earliest study is from 2005, with an upsurge in studies from 2017 onwards. Just under half (n=98, 45.6%) of studies were published in the last 2 years. An overwhelming majority are from the USA (n=178, 82.8%). Europe is the second most common continent with 22 (10.6%) studies of which 9 (4.2%) relate to Dutch healthcare.

The three largest medical specialty groups represented are surgical (n=99; 46.0%), oncology (n=37; 17.2%) and paediatrics (n=19; 8.8%). A complete list of the 215 studies included is summarised in online supplemental appendix. Extracted data are available in online supplemental file.

### Which cost measurement methods are currently being used to facilitate VBHC?

To answer RQ1, we look at how costs were measured. A summary of our findings is presented in table 2. The literature contains many overlapping and contradictory terms, as 'costs' can refer to insurer costs, reimbursements, hospital costs, or patient costs. About half of the studies (n=110, 51.2%) take a provider perspective, with costs calculated for the hospital or care facility. Many studies use charges or payments because hospital cost data are unavailable, considering charges to be a relevant proxy. Some studies use terms such as 'costs', 'charges', 'prices', 'payments' and 'reimbursements' interchangeably, making it difficult to differentiate.<sup>17 18 27-30</sup> For example, Jain *et al*<sup>17</sup> stated, 'The terms reimbursement, cost, and payment have been used interchangeably throughout the text to represent actual amounts paid by insurers.' Similarly, Robles *et al*<sup>30</sup> explained, 'Total hospital charges were used in this standardised costing analysis. Hospital charge data provides a relative measure of the 'cost' of episodes



**Figure 1** PRISMA flow chart depicting the screening, exclusion and inclusion processes with two reviewers. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; VBHC, value-based healthcare.

**Table 1** Characteristics of value-based healthcare studies that measure costs (n=215)

Characteristic	n	%	Characteristic	n	%
<b>Year published</b>			<b>Topic</b>		
2005–2009	3	1.4	Cardiology	5	2.3
2010–2013	6	2.8	Dermatology	1	0.5
2014	6	2.8	Emergency and acute care	11	5.1
2015	7	3.3	Endocrinology	3	1.4
2016	9	4.2	Surgical of which	99	46.0
2017	17	7.9	Appendicitis, 2		
2018	28	13.0	Abdominal, 6		
2019	41	19.1	Bariatric, 2		
2020	43	20.0	Cardiac/thoracic, 12		
2021	51	23.7	Colon/rectal, 2		
2022 as per 1/1/2022	4	1.9	Endocrine, 2		
<b>Geography</b>			Ear/nose/throat, 2		
Americas		84.3	Gallbladder, 2		
Brazil	3		Liver, 2		
Canada	1		Neurosurgical, 5		
US of which	178		Orthopaedic arthroplasty, 25		
Boston, 8			Orthopaedic fracture, 12		
California, 18			Orthopaedic rotator cuff repair, 2		
New York, 23			Orthopaedic other, 3		
Texas, 12			Plastic surgery, 2		
Pennsylvania, 9			Spine, 13		
Other states, 108			other surgical, 5		
Asia		2.3	Geriatrics	1	0.5
China	1		Gynaecology and obstetrics	8	3.7
Iran	1		Infectious disease	1	0.5
Kuwait	1		Internal medicine	12	5.6
Lebanon	1		Multiple	3	1.4
Singapore	1		Nephrology	1	0.5
Europe		10.6	Neurology	2	0.9
Andalusia	1		Oncology	37	17.2
Germany	1		Ophthalmology	3	1.4
Italy	3		Orthopaedic	1	0.5
Norway	1		Pain medicine	3	1.4
Serbia	1		Paediatrics of which	19	8.8
Spain	2		Appendicitis, 3		
Netherlands	9		Emergency and acute care, 2		
UK	4		Neonatal, 3		
Oceania		1.9	Oncology, 1		
Australia	4		Surgical, 5		
Transcontinental		0.9	Surgical, plastic surgery, 2		
Russia	1		Other paediatric, 3		
Turkey	1		Toxicology	1	0.5
			Urology	4	1.9

**Table 2** Characteristics of costing methods in value-based healthcare

Characteristic	Studies		Perspectives	
	n	%	n	%
Cost perspective				
Provider	110	51.2	111	51.6
Insurer	103	47.9	106	49.3
Patient	2	0.9	5	2.3
N	215		222	
	<b>All studies (n=215)</b>		<b>Provider only</b>	<b>Payer only</b>
Cost types included				
Direct	28	13.0	13.0	24
Direct and indirect	177	81.9	81.9	84
Unspecified	10	4.6	4.6	2
Costs measurement implementation				
No, costs measured for purpose of study	34	15.7	15.7	33
Yes, costing method is implemented	39	17.6	17.6	39
Unspecified or not applicable	142	66.2	66.2	38
Costs coverage				
Full care path	47	21.8	21.8	30
Full care path (full surgical episode)	17	7.4	7.4	13
Partial care path (full surgical episode)	22	8.3	8.3	19
Partial care path	86	42.1	42.1	37
Unspecified	43	19.9	19.9	11

Note: N differs between studies and perspectives because seven studies measured two cost types.

of care, as actual cost data are generally not ascertainable in the healthcare setting.<sup>7</sup> When calculating costs using TDABC, Ahluwalia *et al*<sup>31</sup> called these costs ‘prices.’ To try to address this confusion, some recent studies refer to provider costs as the ‘true cost’ of care.<sup>6 7 9 19</sup> Some studies that compare several cost types<sup>19 20</sup> also differentiate ‘traditional hospital accounting’ costs from ‘true costs’ calculated with TDABC.<sup>6 9 20 32 33</sup>

We categorised studies based on the cost types included. Both direct and indirect costs were considered in 177 (81.9%) studies, while 28 (13.0%) papers only included direct costs.

Next, we looked at whether costs were calculated for a complete care path. We found 64 (29.8%) studies that measured costs for a full care path, of which 16 (7.4%) refer to full surgical episodes and label them as such without considering all the presurgical or postsurgical costs. The remaining 86 (42.1%) measure costs of a partial care path.

**Table 3** categorises studies based on the costing method used. In those papers measuring costs within a care provider, we identified two clear categories that were in line with the management accounting literature.<sup>24</sup> The first is ‘direct costing’ (n=23), where direct costs of care are summed and indirect costs ignored. This implies that, if costs cannot be causally attributed to the treatment of a

**Table 3** Overview of cost measurement methods used in value-based healthcare

Perspective	Method	n
Provider	Direct costs only	
	Direct costing	23
	Absorption costing	
	ABC	7
	TDABC	31
Insurer	Other	47
	Not specified	3
	Charges and reimbursements	
Insurer	Charges, reimbursements, claims	81
	Charges adjusted with cost-to-charge ratio	25
Patient	Out-of-pocket costs to patient	5

Note: The total number of studies here is 222 because 7 studies measure two cost types. Studies are classified based on actual costs included and methods described, not necessarily the labels used by the studies’ authors. ABC, activity-based costing; TDABC, time-driven activity-based costing.

specific patient, they are not considered and hence overlooked when making managerial decisions.<sup>24</sup>

The second category of studies considers both direct and indirect costs and uses ‘absorption costing’, whereby indirect costs are allocated to patients based on an allocation key (a type of formula used for allocating indirect costs).<sup>31</sup> These studies include but are not limited to TDABC (n=31) and ABC (n=7), where costs are allocated to individual care activities (such as a consultation or treatment step). The remaining absorption costing papers (n=47) also consider direct and indirect costs but do not report how indirect costs are allocated to activities. In the absorption costing studies, authors may state that cost information was calculated based on diagnosis-related group costs, microcosting, bottom-up clinical costing or hospital accounting systems not further classified. A full list of all the terms used is presented in online supplemental appendix.

### How do these costing methods facilitate VBHC?

To answer RQ2, we extracted all the consequences related to the costing method as described in the papers. Here, like Etges *et al.*,<sup>3</sup> we were looking for how the costing information facilitated VBHC. Note that not all the studies included to address RQ1 describe facilitating VBHC or the consequences of the cost information generated. The reported consequences were grouped inductively, revealing four categories:

1. Identification of cost drivers, in terms of cost items (eg, staff costs, material costs) or activities (eg, surgery, initial consult; n=47).
2. Comparison of costs across patient groups, care providers or procedures (n=38).
3. Measured cost difference or cost saving, while achieving equal or better care (n=26).
4. Suggested or measured care path improvements (n=39).

These studies are presented in table 4. The studies reporting these facilitators used ABC (n=6), TDABC (n=28), other absorption costing methods (n=12) or direct costing (n=3).

### Activity-based costing

The six studies applying ABC justified this on the basis that it was the care provider’s existing costing method. Three of these studies measured costs for a full surgical episode<sup>21 32 34</sup> as part of a longer care path, two measured costs for a full care path,<sup>35 36</sup> and one measured costs of a partial care path.<sup>37</sup> While these studies all applied ABC, the ability to facilitate VBHC differed. Jacobs *et al.*<sup>36</sup> measured costs for a complete care path for patients with adult spinal deformity, a complex care path spanning about 1 year. The authors compared costs across patient groups and patients, identified major cost drivers, and suggested where to concentrate cost containment. Similarly, McLaughlin *et al.*<sup>32 34</sup> measured costs, identified cost drivers and evaluated targeted cost containment initiatives. In one paper,<sup>32</sup> the cost containment

initiatives were informed by the cost information: activities with the highest costs were targeted for savings and a 25% reduction in total costs was achieved. In the other paper,<sup>34</sup> they identified comorbidities and demographics that were strongly related to the total costs of patients undergoing neurosurgery, whereas Wise *et al.*<sup>21</sup> did not for geriatric hip fracture patients while identifying cost drivers and comparing costs across patient groups. Vanni *et al.*<sup>35</sup> successfully predicted about €2 million annual cost savings associated with an enhanced recovery pathway.

### Time-driven ABC

The majority of the papers used to answer RQ2 involved TDABC. Significant cost drivers were identified linked to activities in a care path, and some suggested where to target improvement initiatives.<sup>4 6–8 10 33 38 39</sup> Many of the TDABC studies were able to suggest<sup>6 8 10 19 33 38–51</sup> or measure<sup>5 9 31 52–54</sup> care path improvements (see table 4).

The lengths and specificities of the care path costs varied widely. Some studies were narrow in scope, calculating costs for subsections of a single care path or surgical procedure.<sup>6 8 44 48 55</sup> Isaacson *et al.*<sup>8</sup> calculated costs for cleaning a single reusable piece of equipment, while others costed single surgical days,<sup>6</sup> compared alternative surgesons,<sup>55</sup> or anaesthesia solutions within a care path.<sup>48</sup> Within this group, McClintock *et al.*<sup>44</sup> took the broadest perspective by mapping individual patient journeys.

The largest group (n=10) of TDABC studies measured costs across care paths within a single provider and for a single diagnosis.<sup>9 10 31 33 38 43 45 46 52 54</sup> Typically, these studies compared costs between a new intervention and the ‘usual’ care,<sup>9 10 31 46 53 54</sup> or between alternative care paths<sup>33 38 43 52</sup> in order to measure cost savings.

Some studies were broader in scope, costing multiple care paths or treatments within one specialty,<sup>57 20 51</sup> an entire department,<sup>39 40</sup> multiple practice units<sup>47</sup> or providers.<sup>4</sup> Some compared ‘true costs’ calculated using TDABC across care providers within specialties or care paths,<sup>4 43</sup> while others argued that TDABC costs were too subjective to be compared across hospitals.<sup>10 44</sup> While most studies compared costs across care paths, some also compared costs across patient groups,<sup>19 41 42</sup> or even individual patient journeys.<sup>38 44</sup>

Technology played a prominent role in studies aiming to reduce costs. One study was able to suggest how to use technology more efficiently,<sup>6</sup> and some, by integrating technological investments in the calculated TDABC costs, show how technology can reduce costs.<sup>38 43 46</sup>

Conversely, studies using unspecified absorption methods<sup>56 57</sup> did not include investments in technology, and this is surprising since absorption costing methods require indirect costs to be allocated.

### Analyses enabled by activity-based and TDABC

Several of the ABC and TDABC studies compared costs calculated using traditional accounting costs<sup>6 19 20</sup> or reimbursement amounts<sup>20 21</sup> and found that prices do not equal costs. Some carried out quantitative analyses using cost

**Table 4** Costing method applications, method used and consequences (ordered by year)

Study characteristics		Best practices					Value-based consequences of costing information					
Medical speciality	Costing method	period	Centre	Study type	PM	EI	DO	CG	Compare costs across	ICD	MPS	Care path adjustment
40	Internal medicine	Partial	Single	Retro	Yes	Yes		Items, activities		Yes		Suggested
33	Surgical, orthopaedic, rotator cuff repair	Full (FSE)	Single	Retro	Yes	Yes	Yes	Items, activities	Surgeons, two alternative treatments	Yes	Yes, ±US\$727 about the mean per patient	Suggested
4	Cardiology, surgical	Full (FSE)	Multi	Retro	Yes	Yes	Yes	Items, activities	Hospitals, procedures	Yes	Yes, estimate 51.0% of procedure cost	Yes
10	Oncology	Full	Single	Retro	Yes	Yes	Yes	Items, activities	Treatment care paths	Yes	US\$2302 (25.0%) difference across treatments	Suggested
41	Surgical, orthopaedic	Full (FSE)	Single	Retro	Yes			Items, activities	Patients	Yes		Suggested
19	Surgical, orthopaedic	Full (FSE)	Single	Retro	Yes	Yes	Yes	Items, activities	Costing methods (TA and TDABC)	Yes		Suggested
20	Surgical, orthopaedic	Full (FSE)	Single	Retro	Yes	Yes	Yes	Items, activities	Five treatments, cost vs reimbursement	Yes		Suggested
43	Paediatric, surgical, plastic surgery	Full (FSE)	Multi	Pro	Yes	Yes	Yes	Items, activities	Treatment care paths	Yes	Up to US\$900, but long-term outcomes yet unknown	Suggested
44	Emergency and acute care	Full (multiple)	Multi	Retro	Yes	Yes	Yes	Items, activities	Eight care paths for acute ureteral stones (patient journeys)	Yes	Yes, US\$6614 difference across care paths	Suggested
55	Surgical, orthopaedic	Full (FSE)	Single	Retro	Yes	Yes	Yes	Items, activities	Surgeons	Yes		Suggested
38	Oncology	Partial	Single	Pro	Yes	Yes	Yes	Items, activities	Treatments and individual care paths	Yes	Yes, cost difference of up to 3.33 times, depending on case mix	Suggested
45	Oncology (incl. surgery)	Full	Single	Retro	Yes		Yes	Items, activities		Yes		Suggested
52	Oncology	Partial (FSE)	Single	Retro	Yes			Items	Preimplementation and postimplementation	Yes	Yes, mean cost savings of €309 per patient	Yes
65	Cardiology	Partial	Multi	Retro				Items	Patient journeys	Yes		Suggested
66	Emergency and acute care	Partial	Single	Retro	Yes			Items	Surgeons	Yes		Suggested
67	Surgical, bariatric	Full (FSE)	Single	Retro				Items	Treatment	Yes		Suggested
68	Gynaecology and obstetrics	Full	Single	Retro	Yes			Items, activities	Procedures	Yes	Yes, \$967 per patient	Suggested
58	Emergency and acute care	Partial	Single	Retro				Items, activities		Yes		Suggested
69	Surgical, colorectal	Partial (FSE)	Single	Retro				Items	Intervention	Yes	Yes, reduced variable cost, similar total cost	Yes
21	Surgical, orthopaedics, fracture	Partial (FSE)	Single	Retro				Items	Patients, patient groups, demographics	Yes		Suggested
35	Surgical, orthopaedic, arthroplasty	Full (FSE)	Single	Both		Yes	Yes	Items, activities	Treatment care paths	Yes	Estimate €2 054 000 annually	Yes

Continued

Table 4 Continued

Study characteristics		Best practices					Value-based consequences of costing information			
		ABC	Full	Single	Retro	Yes	Items, activities	Patients, patient groups	Yes	Suggested
36	Surgical, spine	ABC	Full	Single	Retro	Yes	Items, activities	Patients, patient groups	Yes	Suggested
6	Paediatric, surgical	TDABC	Full (FSE)	Single	Both	Yes	Items, activities	Costing methods (TA and TDABC)	Yes	Suggested
46	Oncology	TDABC	Full (FSE)	Single	Retro	Yes	Items, activities	Treatment care paths	Yes	Suggested
									Yes, estimate for each 10.0% decrease in case duration, total costs could decrease by about 8.0%.	
31	Surgical, orthopaedic	TDABC	Full (FSE)	Single	Pro	Yes	Items, activities	Treatment care paths	Yes	Suggested
53	Paediatric, neonatal	TDABC	Partial	Single	Retro	Yes	Items, activities	Pre and post intervention	Yes	Yes
									Yes, 36.0% or US\$92 000 per tracheostomy care cycle	Yes
70	Surgical, cardiac/thoracic	AC (other)	Partial	Multi	Retro	Yes	Items	Patients, implant devices	Yes	Suggested
71	Oncology, surgical	AC (other)	Partial	Single	Retro	Yes	Items	Items	Yes	Yes, multiple
47	Multiple	TDABC	Full	Multi, pilot	Retro	Yes	Items, activities	Before and after intervention (IPUs)	Yes	Yes, quarterly costs declined
48	Oncology	TDABC	partial (PSE)	Single	Pro	Yes	Items, activities	Treatment care paths (parallel vs induction design in OR)	Yes	Yes, estimate OR time reduction of 55 min, or US\$2818 missed revenue
49	Surgical, orthopaedics fracture	TDABC	partial (FSE)	Single	Both	Yes	Items	Items	Yes	Suggested
50	Surgical, foot debridement	TDABC	partial (FSE)	Single	Retro	Yes	Items	Before and after intervention	Yes	Yes
39	Ophthalmology	TDABC	full	Single	Retro	Yes	Items, activities	Items, activities	Yes	Suggested
56	Gynaecology and obstetrics, surgical	AC (other)	partial (FSE)	Single	Retro	Yes	Items	Items	Yes	Suggested
57	Gynaecology and obstetrics, surgical	AC (other)	partial (FSE)	Single	Retro	Yes	Items	Items	Yes	Suggested
60	Multiple	Direct costing	partial	Single	Retro	Yes	items	items	Yes	Yes
61	Surgical, orthopaedic	Direct costing	full (FSE)	Multi	Retro	Yes	Items	Intervention	Yes	Yes, £255 per patient
5	Surgical, carpal tunnel release	TDABC	partial (FSE)	Multi	Retro	Yes	Items, activities	Multiple treatment care paths	Yes	Yes, 70.9% (US\$27,103) and 31.6% (US\$178)
59	Surgical, appendicitis	AC (other)	partial (FSE)	Single	Pro	Yes	Items	Pre and post intervention (dashboard)	Yes	Yes, decreased by \$496 per operation
62	Surgical, orthopaedic	Direct costing	partial (FSE)	Single	Retro	Yes	Items	Intervention	Yes	Yes, estimate 2 hours per cycle
8	Urology	TDABC	partial	Single	Pro	Yes	Items, activities	Items, activities	Yes	Suggested
54	Paediatrics, appendicitis	TDABC	full (FSE)	Single	Pro	Yes	Items, activities	Treatment care paths (pre and post intervention)	Yes	Yes, several
									Yes, 11.0% cost reduction, and 51.0% hospitalisation time reduction	Yes, several
72	Urology	AC (other)	partial	Multi	Retro	Yes	Items	Items	Yes	Suggested

Continued



**Table 4** Continued

Study characteristics			Best practices				Value-based consequences of costing information						
7	Oncology, surgical, 11 surgeries	TDABC	Partial (FSEs)	Single	Retro	Yes	Yes	Items, activities	Potential staffing ratios	Yes	Estimate 13.0%–28.0% per surgery type	Modelled and suggested	
9	Oncology	TDABC	full	Single	Retro	Yes	Yes	Items, activities	Treatments (high-dose vs low-dose brachytherapy)	Yes	US\$2668 difference across treatments	Yes	
51	Urology	TDABC	partial (FSE)	Single	Retro	Yes	Yes	Items, activities	Five treatment care paths	Yes	Yes, 400.0% increase from least to most expensive pathways	Suggested	
32	Surgical, neurosurgery	ABC	partial (FSE)	Single	Retro	Yes	Yes	Items, activities	Patients	Yes	Yes, 25.0%	Yes, several	
34	Surgical, neurosurgery	ABC	partial (FSE)	Single	Retro	Yes	Yes	Items, activities	patients	Yes		Suggested	
37	Paediatric plastic surgery	ABC	partial, 1 year	Single	Retro	Count	33	17	24	38	47	26	39

Costing methods are classified based on actual reported costs and methods applied, not necessarily the labels used by authors. ABC, activity-based costing; AC, absorption costing; CG, cost grouping; DO, direct observation; EI, expert input; FSE, full surgical episode; MPS, measured provider cost savings; PM, process mapping; Pro, prospective; PSE, partial surgical episode; Retro, retrospective; TDABC, time-driven activity-based costing.

information generated using ABC or TDABC including regression analyses to identify correlations,<sup>7 33 38 41 42</sup> compare patient groups,<sup>20 41 42</sup> and compare costs and outcomes across a matched patient sample.<sup>38</sup>

Two recent studies<sup>33 49</sup> have conducted patient-level value analyses, comparing patient-reported outcomes with patient-level TDABC costs. Wise *et al*<sup>33</sup> did so for rotator cuff repair surgery over a period of 1 year, while McCreary *et al*<sup>49</sup> analysed ankle fractures. Both studies found costs to be unrelated to patient-reported outcome measures, highlighting the need for further research. This suggests that patient-reported outcome measures are not strongly associated with the costs of the care delivered, and that patient satisfaction may depend on other factors such as their perceived experience with healthcare professionals.

#### Other absorption costing methods and direct costing

Other absorption costing methods reported in the studies were labelled as microcosting (n=5), bottom-up clinical costing<sup>58</sup> or were described but not labelled (n=6). Most were able to identify cost drivers (n=12, for details, see table 4) and some compared costs within providers. Notably, Robinson *et al*<sup>59</sup> used the cost information to build and evaluate a dashboard that provides real-time feedback to surgeons during operations and monthly summaries and thereby decreases costs significantly. Some studies omitted certain cost categories such as equipment.<sup>57</sup> Direct costing enabled cost drivers to be identified,<sup>60–62</sup> and in some cases granular cost measurement.

#### Best practices

Having identified these four facilitators, we compared studies to find common practices. This is particularly useful because costing methods are not labelled consistently. For example, many studies refer to ABC as ‘bottom-up costing.’ To look beyond labels, we compared the actual methodologies used to measure costs. We found that studies that were able to facilitate VBHC used process mapping (n=33), expert input (n=17) and/or direct observations (n=24) when measuring costs. These practices overlap with TDABC best practices, but are not exclusive to TDABC, as shown in table 4.

Studies that made specific care path improvement suggestions used process mapping, and especially those involving multidisciplinary teams reported significant benefits.<sup>4 9 10 19</sup> This approach enabled experts (doctors, care professionals, administrators) with the required knowledge and experience to reflect critically on the process,<sup>4 9 10 19</sup> resulting in actionable suggestions. In comparison, studies that did not use process mapping tended to suggest minimising high-cost items (eg, total operating time, nursing costs) but were unable to couple these suggestions to specific activities or to chronological points in the care path. Commenting only on cost items, and not identifying chronological points, limits the ability of cost information to steer management towards where to focus process improvement initiatives.

Expert input while creating process maps or measuring costs was often cited by authors as valuable, especially for estimating preparation time or other behind-the-scenes activities that do not involve the patient but are critical to delivering care. Some studies that could not call on expert input cited this as a limitation. A few cases also evaluated the impact of costing information, for example by involving experts to evaluate a dashboard.<sup>59</sup>

Finally, some studies involved direct observations, particularly those that calculated process times to the minute or measured the costs of individual patient journeys.

## DISCUSSION

This review focused on VBHC studies that have measured or estimated costs, and on identifying which costing methods can facilitate VBHC. By assessing the consequences of the costing methods used, we were able to identify characteristics of costing methods that do facilitate VBHC.

Previous research found that TDABC can facilitate VBHC through cost containment and process improvements.<sup>3 15</sup> We built on this by comparing value-based consequences across costing methods. While the field is young and alternatives seem limited, we have found considerable evidence that TDABC and ABC can indeed facilitate VBHC. As previously noted, TDABC is considerably easier to implement than ABC, which leads us to recommend it over ABC. We found no well-documented alternatives to TDABC or ABC in our review. However, not all the TDABC studies delivered the facilitating factors we have identified. We, therefore, emphasise the need to follow TDABC guidelines carefully and to explicitly document methods used. Several of the studies in this review simply stated that TDABC was applied, outsourced, used with incomplete costs, or used without listing exact cost rates.

The start and end points of care paths tend to be well documented by authors but are inconsistent. To view costs in relation to outcomes, as suggested by Porter,<sup>2</sup> the total costs from start to finish of a trajectory should be included.<sup>63</sup> In many studies, the start and end points of cost measurement windows seem somewhat arbitrary but are still labelled as full care paths. Consequently, this results in inconsistencies across studies, hindering comparisons. Encouragingly, some of the more recent studies have measured costs across a genuine full care path and future research should do the same, explicitly defining start and end points. This would enable consistent comparisons across providers. As with the ICHOM standard outcome sets produced by the International Consortium for Health Outcomes Measurement, costs could be catalogued and compared over full care paths. Indeed, in a recent expert consensus study, experts agreed on the need to focus on full care paths.<sup>63</sup>

Furthermore, we can see a trade-off in the specificity and length of the care path costed. Studies that measure costs for elements of a care path (such as a surgical

operation) can provide detailed costs for that portion of the care path, but not total care costs for a patient because the remainder of the care path is not included. Some surgical studies measured costs for partial care paths, and often concluded that operating theatre time should be minimised due to high surgeon and operating theatre costs. However, this conclusion has limited relevance for the value equation<sup>13</sup> because it does not provide cost information for an entire care path, or advice on how to circumvent surgery.

Studies that cost complete care paths appear to use less-detailed costing methods (due to the sheer length of the care path) but are able to compute total costs of a patient's care. This enabled benchmarking across providers, as well as cost comparisons of new versus standard care, or of treatment alternatives. This allowed providers to steer towards lower-cost outcomes to maximise value. Future research should focus on measuring costs for full care paths, and on comparing costs to outcomes as demonstrated in some of the more recently published studies in our review.<sup>33 38 49</sup>

Our review highlights the need to involve medical professionals in this process, both when implementing costing methods as well as when evaluating the results. Future cost measurement studies, and hospitals looking to implement TDABC, should involve multidisciplinary teams. Studies that have involved medical professionals in the process of measuring costs and then using the findings were able to improve care paths through improvement initiatives and/or dashboards. This suggests that generating and using costing information should be viewed as a process. Future qualitative research should follow this process to better understand the mechanisms through which cost information impacts decision making, and the impact that staff involvement has on cost containment. Previous research suggests that staff involvement is critical as it builds trust in the accuracy of the data.<sup>64</sup>

## Limitations and future research

We must acknowledge several limitations related to the scope, breadth and quality of the included studies. First, our search strategy will have missed studies that measure costs but do not label the study as VBHC-oriented. Not all TDABC studies make value-based claims or contributions and may therefore be overlooked in our review. In addition, not all studies explicitly discuss the impact or consequences of the costing method applied, which may impact our findings. Future qualitative research could usefully investigate TDABC implementations and evaluate whether the facilitating factors found in this review are achieved. Second, sophisticated methods such as TDABC are currently only used with predictable and/or short care paths such as orthopaedic surgery. Further research testing the feasibility and practicality of TDABC in different settings, such as emergency on-call care, or longer care paths such as fertility treatment, is warranted. Further, our findings may have limited generalisability across medical specialties as indicated in [table 1](#). Finally,

we have relied on the reporting of authors whose style and quality differs across disciplines and journals. To an extent we circumvented this limitation by looking beyond the cost measurement labels used by authors, extracting the costs included and methods used, and then categorising them using established accounting definitions. However, we cannot exclude the possibility of errors due to a lack of explicit reporting in some of the studies reviewed.

## CONCLUSIONS

This systematic review reveals that cost information, at the treatment or patient level, for complete care paths does enable value-based decision making through several mechanisms. Such cost information can direct quality and process improvement initiatives alongside informing appropriate reimbursement levels. In the pursuit of VBHC, practitioners and academics are advised to apply ABC or TDABC to estimate costs, using process mapping, expert input and observations, rather than relying on pricing information.

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