**CSIRO** PUBLISHING
*Australian Health Review*
https://doi.org/10.1071/AH18102

# Cost of vascular access devices in public hospitals in Queensland

*Haitham W. Tuffaha*[1,2] BPharm, MBA, MSc, PhD, Senior Research Fellow
*Nicole Marsh*[3,4,5] RN, BN, MAdvPrac(Healthcare Research), PhD Candidate, Research Fellow
*Joshua Byrnes*[2] BEcon, BComm, MEcon, MHealthEcon, PhD, Associate Professor of Health Economics, Senior Research Fellow
*Nicole Gavin*[3,4,5] RN, BSc(Hons), MAdvPrac(Healthcare Research), PhD Candidate, Nurse Researcher
*Joan Webster*[3,4,5] RN, BA, Director of Nursing and Midwifery Research
*Marie Cooke*[4,5] RN, PhD, Professor of Nursing
*Claire M. Rickard*[3,4,5] RN, PhD, FAHMS, FACN, Director AVATAR

[1]Menzies Health Institute Queensland, Griffith University, Qld 4111, Australia. Email: Haitham.tuffaha@griffith.edu.au
[2]Centre for Applied Health Economics, School of Medicine, Nathan Campus, Griffith University, Qld 4111, Australia. Email: j.byrnes@griffith.edu.au
[3]Nursing and Midwifery Research Centre, Royal Brisbane and Women's Hospital, Herston, Qld 4006, Australia. Email: nicole.marsh@health.qld.gov.au; nicole.gavin@health.qld.gov.au
[4]Alliance for Vascular Access Teaching and Research (AVATAR), Menzies Health Institute Queensland, Griffith University, Brisbane, Qld, Australia. Email: m.cooke@griffith.edu.au; c.rickard@griffith.edu.au
[5]School of Nursing and Midwifery, Griffith University, Nathan Qld 4111, Australia.
[6]Corresponding author. Email: joan.webster@heath.qld.gov.au

**Abstract**

**Objective.** The aim of this study was to quantify the utilisation of vascular access devices in Queensland public hospitals and their associated cost.

**Methods.** Devices were broadly classified into peripheral intravenous catheters, central venous catheters and arterial lines. The number of catheters used was obtained from a central procurement department at Queensland Health and validated using Medicare Benefits Schedule (MBS) claims and/or hospital data from the Australian Institute of Health and Welfare for the same period. Resources consumed included equipment and staff time required to insert and remove catheters. Equipment costs were valued using negotiated hospital prices, and staff time was valued at the fixed industrial award wages in Australia or relevant MBS fees. Device maintenance costs (e.g. dressings) and costs of treating complications were excluded.

**Results.** Approximately 2.75 million vascular access devices were used in public hospitals in Queensland in 2016, at a total cost of A$59.14 million. This comprised a total equipment cost of around A$10.17 million and a total labour cost of A$48.85 million

**Conclusion.** Vascular access is an important component of healthcare expenditure. The present study is the first to characterise and cost vascular access devices in Queensland. Further research is needed on the costs of maintaining device function and of treating complications associated with vascular access.

**What is known about the topic?** The cost of vascular access in Australia has previously been estimated from modelling, using various assumptions, or based on device utilisation in other countries.
**What does this paper add?** For the first time, device utilisation for vascular access in Queensland has been quantified and costed. Results were obtained from reliable sources and validated against other databases.
**What are the implications for practitioners?** Practitioners and managers may now provide accurate estimates about the cost of catheter failure, a potentially preventable problem that affects up to 50% of all catheters placed. Attaching costs to such failure may also stimulate research into how to reduce the problem.

**Additional keywords:** economic evaluation, equipment costs, intravenous catheterisation, staff costs.

Received 12 December 2017, accepted 31 July 2018, published online 4 September 2018

 

## Introduction

The history of vascular access is long, spanning five centuries. The first animal-to-animal transfusions occurred in the mid-1600s, and experimental infusions of medications, delivered via a quill, began in the same century.[1–3] However, it was not until 1818 that the first successful blood transfusion was performed, following a postpartum haemorrhage.[3] Since then, devices for the delivery of parenteral treatment through the human vasculature has continued to develop. Important milestones included the replacement of rubber tubing for delivering fluids with plastic tubing, the use of vacuum bags to reduce the risk of microbial growth in intravenous solutions and the development of hollow steel needles, which were replaced in the 1950s by polyethylene devices[3,4] and later by latex rubber, polytetrafluoroethylene, polyurethane and silicone, including various antimicrobial- and antithrombogenic-coated or -impregnated devices.

In the modern era, several types of vascular access devices (VADs) are in use. The most common is the peripheral intravenous catheter (PIVC), which is a small, flexible tube placed in a peripheral vein and secured to the skin with an adhesive dressing plus tape or a securement device. PIVCs are designed for short-term use to deliver medications and fluids. Central venous access devices (CVAD) are used when longer-term therapy, such as chemotherapy or haemodialysis, is required; CVAD are long, flexible tubes placed in large veins of the neck, chest or groin. These catheters may also be inserted into a peripheral vein in the arm, known as peripherally inserted central catheters (PICC). CVADs, including PICCs, may be either non-tunnelled or tunnelled. Non-tunnelled catheters are fixed to the skin, as with PIVCs, at the insertion site. Tunnelled catheters, as the name suggests, are tunnelled under the skin, from the insertion site to an exit site, often on the chest. Tunnelling enables a patient on long-term therapy to be discharged from hospital with the device *in situ*, whereas a non-tunnelled device is usually removed before hospital discharge. A totally implanted vascular device is a smaller reservoir port device, surgically positioned in the vein and entirely under the skin. This device requires access with a needle through the skin into the port. These devices are used for long-term therapy, such as for the frequent administration of drugs, parenteral nutrition or transfusions. Medications are administered through the skin into the port, to reduce the chance of catheter-related infection.[5] Midline catheters fall between PIVCs and CVADs in terms of length, at around 8–12 cm, and are placed in the upper arm. The dwell time may be up to up to 30 days, which is similar to a PICC; the use of midline catheters is also similar to that of PICCs, that is, for the administration of medium-term therapies. The advantage of a midline catheter over a PICC is that the tip placement is proximal to the axilla, so the central venous system is not entered, thus reducing the risk of a catheter-related bloodstream infection.[6] Finally, peripheral arterial catheters (AC) are thin tubes, usually placed in the radial or femoral artery, that are used for monitoring intra-arterial blood pressure and arterial blood gases. Their use is short term and usually limited to intensive care or anaesthetic settings.

Although much is known and documented about the development of VADs, particularly when a new product comes onto the market, less is known about the volume used. It is not uncommon to find statements claiming that up to 70% of hospital patients receive a PIVC[7] or about the wide use of PICCs in cancer patients,[8] but quantifying the use of total devices is more difficult. Some reports contain specific details, such as up to 25 million PIVCs are placed in France every year[9] or that around 330 million PIVCs are sold in the US each year,[10] but these statements are frequently based on citations from earlier reports, which themselves are often unclear estimates. For example, information for the French reference above was extracted from a 2005 report but, in that report, it was unclear from where the estimate of 25 million catheters came.[11] Similarly, the US data were cited from a 2012 publication that cited 330 million catheters, based on unpublished industry estimate of sales.[12]

In an Australian context, we have no large-scale evidence about the annual use of VADs and their cost. Without this information it is not possible to estimate savings that could be made if intravenous practices could be improved. For example, many inserted devices are never used,[13] and around 25% of insertions require multiple attempts, particularly in those patients who are difficult to cannulate, such as the obese and those who have vascular damage due to age or frequent cannulation.[14] In addition, up to 50% of devices fail for various reasons, such as phlebitis, occlusion, infiltration, blockage or dislodgement before treatment has been completed,[7] requiring a replacement device. Being able to apply a cost value to these problems may incentivise organisations to be more proactive in preventing unnecessary catheter insertion, to use expert inserters to increase the likelihood of first-attempt success and to optimise postinsertion care to prevent device failure. Consequently, the aim of the present study was to quantify the use of various VADs in Queensland public hospitals and the associated cost.

## Methods

Our approach was to identify, measure and value the VADs used from the perspective of the State Health Department, Queensland Health.

We broadly classified devices into PIVCs, CVADs and ACs. CVADs were subdivided into PICCs, tunnelled and non-tunnelled central venous catheters and implanted ports. Midline catheters were not included in the study because midline catheters are not purchased for use in Queensland public hospitals. To estimate the annual number of devices used by public hospitals in Queensland, purchase data were used as a proxy for the volume of utilisation. The number of devices purchased in 2016 was obtained from the Strategic Procurement and Supply Service at Health Support Queensland, which is the central department for purchasing and distributing devices to public hospitals in Queensland. Purchase data were obtained from this department through an official data request.

Health resources consumed included equipment and staff time required to insert and remove catheters. Equipment costs were valued using negotiated hospital prices in 2016 for both the catheter sets and insertion-related accessory devices (e.g. guidewires). In the presence of multiple brands of the same device type, the weighted average prices were calculated based on the number of catheters consumed of each brand. Staff time associated with PIVC use was estimated at 15 min for insertion and 4.5 min for removal,[15] with time valued based on 2016 fixed industrial award wages in Australia. Staff time for inserting and removing other VADs and ACs was valued based on Medicare Benefits Schedule (MBS) fees in 2016 (Table 1). Device to MBS item match was guided by expert opinion (NM and NG) and verified independently by a claim unit in a leading hospital in Brisbane. We did not include the costs of maintaining VADs while in use (e.g. infusion therapy or dressings used). All costs are reported in Australian dollars (A$) in 2016 prices (A$1 = US$0.75).

To validate our results, we compared our estimates of the number of devices consumed with the number of relevant MBS claims and/or hospital data from the Australian Institute of Health and Welfare (AIHW) for the same period.

## Results

Approximately 2.75 million VADs were used in public hospitals in Queensland in 2016 at a total cost of A$59.14 million. Most catheters used were PIVCs (2 690 000; 97.8%) followed by ACs (33 700; 1.2%) and CVADs (26 500; 1.0%).

Total equipment cost was around A$10.17 million, with A$6.13 million (60.2%) for PIVCs, A$3.31 million (32.5%) for CVADs and A$0.73 million for ACs (7.3%). Total labour cost was A$48.85 million, with A$34.92 million (71.5%) for PIVCs, A$9.26 million (19.0%) for CVADs and A$4.66 million (9.5%) for ACs. Table 2 summarises total costs for the devices included in the present study.

Our estimates of device utilisation were close to the estimates obtained from other data sources (within a 10% margin). For example, using an epidemiological approach based on the number of hospitalised patients from the AIHW (for details, see Table 3), approximately 2.4 million PIVCs could be used annually in public hospitals in Queensland.[16] Furthermore, using MBS claims for Queensland in 2016 indicated that around 10 241 PICCs (vs 9757 from the present study), 667 tunnelled catheters (vs 535) and 33 000 arterial lines (vs 33 657) would be used each year.[17] Table 3 compares device utilisation estimates from various data sources.

## Discussion

This study is the first to characterise the number and cost of VADs used in Queensland. Many of these devices (up to 50%) are only used because a previous device in that patient failed. Thus, we may also begin to calculate costs associated with both insertion failure and postinsertion device failure, as well as placement of unnecessary devices.[7,18,19] Putting a figure around this waste may prompt a greater emphasis on finding solutions to vascular access challenges. The study is also important because it provides an insight into the types of VADs used in Queensland, which may allow for comparisons with other jurisdictions where similar practices are adopted. For example, midline catheters are rarely used in Australia, but are used elsewhere as an alternative to inserting a PICC or to avoid frequent PIVC replacement. There are now evidence-based

**Table 1. Insertion and removal costs in Australian dollars for the various devices**

VAD, vascular access device; PIVC, peripherally inserted venous catheter; PICC, peripherally inserted central catheter; MBS, Medicare Benefits Schedule

| VAD | Insertion costs (A$) | Source | Removal costs (A$) | Source |
|---|---|---|---|---|
| PIVCs | 10.00 | Based on insertion time of 15 min and a weighted hourly wage of $40[15] | 3.00 | Based on removal time of 4.5 min and a weighted hourly wage of A$40[15] |
| PICCs | Adult: 83.00 | MBS Items 13815 and 22020 | Adult: 204.00 | MBS Item 34530 |
| | Paediatric[A]: 227.50 | MBS Items 13318 and 13319 | Paediatric: 265.50 | MBS Item 34540 |
| Tunnelled | Adult: 272.40 | MBS Item 34528 | Adult: 204.00 | MBS Item 34530 |
| | Paediatric: 354.00 | MBS Item 34534 | Paediatric: 265.50 | MBS Item 34540 |
| Non-tunnelled | Adult: 83.00 | MBS Items 13815 and 22020 | Adult: 204.00 | MBS Item 34530 |
| | Paediatric[B]: 227.50 | MBS Items 13318 and 13319 | Paediatric: 265.50 | MBS Item 34540 |
| Implanted ports | Adult: 551.60 | MBS Item 34527 | Adult: 204.00 | MBS Item 34530 |
| | Paediatric: 717.10 | MBS Item 34529 | Paediatric: 265.50 | MBS Item 34540 |
| Arterial lines | 69.30 | MBS Item 13842 | 69.30 | MBS Item 13842 |

[A]Paediatrics used PICCs of <5 Fr.
[B]Paediatrics used non-tunnelled catheters of <6 Fr.

**Table 2. Summary of vascular access device use and cost in public hospitals in Queensland in 2016 (Health Services Queensland procurement numbers)**

PIVC, peripherally inserted venous catheter; PICC, peripherally inserted central catheter

| Type | No. catheters | Equipment cost (A$) | Labour cost (A$) | Accessories cost (A$) | Total cost (A$) |
|---|---|---|---|---|---|
| PIVC | 2 686 315 | 6 131 701 | 34 922 095 | | 41 053 796 |
| Tunnelled | 535 | 115 611 | 271 903 | 5490 | 393 003 |
| PICC | 9757 | 1 232 229 | 3 307 843 | 4984 | 4 545 056 |
| Non-tunnelled | 14 081 | 1 049 979 | 4 145 641 | 86 350 | 5 281 970 |
| Implanted ports | 2026 | 911 700 | 1 537 656 | | 2 449 356 |
| Arterial | 33 657 | 733 797 | 4 664 860 | 21 379 | 5 420 036 |
| Total | 2 746 371 | 10 175 017 | 48 849 998 | 118 202 | 59 143 217 |

**Table 3. Results validation with other data sources for device utilisation**

HSQ, Health Services Queensland; AIHW, Australian Institute of Health and Welfare; PIVC, peripherally inserted venous catheter; PICC, peripherally inserted central catheter; MBS, Medicare Benefits Schedule

| Device | No. from HSQ | Validation | Validation using other data sources |
|---|---|---|---|
| PIVCs | 2 686 315 | 2 375 000 | Based on AIHW,[21] approximately 1.3 million separations (0.6 million overnight) were recorded in public hospitals in Queensland; assuming one catheter inserted for the same day (700 000 × 1) and two catheters over the average (LOS) of 5 days in overnight separations (600 000 × 2) and adjusting for 25% failure rate that requires replacement |
| PICCs | 9757 | 10 241 | 2016 MBS claims for Items 13815, 13318, 22020, 13319 from Queensland |
| Tunnelled | 535 | 667 | 2016 MBS claims for Items 34528, 34534 from Queensland |
| Arterial lines | 33 657 | 30 000 | 2016 MBS claims for Items 13842, 13876, 22012, 22014, 11600 from Queensland, which is 75 000 arterial blood pressure monitoring episodes 2–3 times per day |

indications for the use of midline catheters;[20] the use of these devices may reduce costs, avoid multiple PIVC insertions and prevent complications associated with central venous access.

We have shown that the total annual cost of vascular access is nearly A$ 60 million in public hospitals in Queensland. Based on the Admitted Patient Care Report 2015–2016 by the Australian Institute of Health and Welfare, there were 1 292 391 separations in public hospitals in Queensland;[21] thus, the cost per separation is around A$46. These estimates approximate the VAD cost in public and private hospitals in Queensland and in Australia. For example, the number of separations in private hospitals in Queensland in 2015–16 was 1 072 557;[21] thus, the separation distribution of the 2 364 948 episodes in public and private hospitals is 55% public : 45% private.[21] Accordingly, and assuming similar practices across hospitals in the State, the cost of vascular access in Queensland's private hospitals is around A$50 million, and the total annual cost in both private and public hospitals is around A$110 million. Given that the total acute public and private hospital separations in Queensland represent 22% of the 10 585 288 total hospital separations in Australia,[21] the total annual cost of VADs in the country may be around A$500 million. This number is expected to increase with population growth.

Importantly, with currently substantial rates of potentially preventable device failure, A$90–180 million dollars could be saved annually in Australia by improving VAD practices.

## Strengths and limitations

A major strength of the present study is that data were derived from one source, a central department in Queensland Health, using negotiated hospital prices, which means that we did not have to model or make many assumptions to estimate device utilisation. Furthermore, the results were validated using other data sources (e.g. MBS claims and/or hospital data from the AIHW when available). Using MBS claims instead of the figures from the central procurement unit may not be accurate because not all the devices included in the present study can be claimed through the MBS. For example, there is no MBS item for PIVCs. However, the results were verified by experts and compared with other data sources.

There were some limitations to the study. Data were from one jurisdiction (public hospitals in Queensland); however, this should not differ much from the practice in other states. Further, certain assumptions were made to match MBS items to devices, especially that some MBS items were used for more than one device type; however, this was informed by expert opinion. Moreover, it was beyond the scope of this study to include the cost of maintaining devices while in place (e.g. dressings or flushing) or the cost of diagnosing and treating complications, such as primary bloodstream infections, which have a current cost of A$6351.94,[21] or of troubleshooting complications, such as expensive antithrombolytics for catheter occlusion. If these costs were added, the overall burden of catheter use and failure would be much higher, and further research is needed to provide a full picture. Another limitation is that other types of devices (e.g. midline or intraosseous device) were not included in the study. However, these are not used as commonly as the catheters included in the analysis, and therefore may not significantly alter the overall conclusions of the paper. Finally, there is an inherent difference between procurement and utilisation; that is, what is purchased is only a proxy for what is used. However, inventory levels are likely to remain stable with just-in-time procurement and so it is unlikely that over the observation period stock-on-hand levels were likely to differ significantly between the beginning and end of the period. Therefore, procurement of devices is likely to be a very close proxy for utilisation.

### *Implications for research and practice*

A national clinical registry designed to document VAD utilisation and capture outcomes associated with various devices would be useful to inform practice and policy decisions about device selection and improved quality and safety of care. To decrease the incidence of device failure, further research into insertion and postinsertion strategies (e.g. securement) is also required. In addition, to reduce the number of devices placed, health system policies should be updated to reflect existing evidence related supporting clinically justified rather than routine time-based removal of PIVCs, so unnecessary waste and procedures may be avoided.

## Conclusion

Vascular access is an important component of healthcare expenditure. The present study is the first to characterise and cost the use of VADs in Queensland.

## Conflict of interest

The authors declare no conflicts of interest.

## Acknowledgements

The study had no external funding.


## References


1 Biffi R. History of vascular access. In: Di Carlo I, Biffi R, editors. Totally implantable vascular access devices. Milan: Springer-Verlag; 2012. pp. 3–9.

2 Millam D. The history of intravenous therapy. *J Intraven Nurs* 1996; 19: 5–14.

3 Rivera AM, Strauss KW, van Zundert A, Mortier E. The history of peripheral intravenous catheters: how little plastic tubes revolutionized medicine. *Acta Anaesthesiol Belg* 2005; 56: 271–82.

4 Duffy BJ Jr. The clinical use of polyethylene tubing for intravenous therapy; a report on 72 cases. *Ann Surg* 1949; 130: 929–36. doi:10.1097/00000658-194911000-00008

5 Hord JD, Lawlor J, Werner E, Billett AL, Bundy DG, Winkle C, Gaur AH. Central line associated blood stream infections in pediatric hematology/oncology patients with different types of central lines. *Pediatr Blood Cancer* 2016; 63: 1603–7. doi:10.1002/pbc.26053

6 Adams DZ, Little A, Vinsant C, Khandelwal S. The midline catheter: a clinical review. *J Emerg Med* 2016; 51: 252–8. doi:10.1016/j.jemermed.2016.05.029

7 Marsh N, Webster J, Larsen E, Cooke M, Mihala G, Rickard C. Observational study of peripheral intravenous catheter outcomes in adult hospitalized patients: a multivariate analysis of peripheral intravenous catheter failure. *J Hosp Med* 2018; 13: 83–9. doi:10.12788/jhm.2867

8 Kang J, Chen W, Sun W, Ge R, Li H, Ma E, Su Q, Cheng F, Hong J, Zhang Y, Lei C, Wang X, Jin A, Liu W. Peripherally inserted central catheter-related complications in cancer patients: a prospective study of over 50,000 catheter days. *J Vasc Access* 2017; 18: 153–7. doi:10.5301/jva.5000670

9 Miliani K, Taravella R, Thillard D, Chauvin V, Martin E, Edouard S, Astagneau P. CATHEVAL Study Group. Peripheral venous catheter-related adverse events: evaluation from a multicentre epidemiological study in France (the CATHEVAL Project). *PLoS One* 2017; 12: doi:10.1371/journal.pone.0168637

10 Rickard CM, Marsh N, Webster J, Playford EG, McGrail MR, Larsen E, Keogh S, McMillan D, Whitty JA, Choudhury MA, Dunster KR, Reynolds H, Marshall A, Crilly J, Young J, Thom O, Gowardman J, Corley A, Fraser JF. Securing All intraVenous devices Effectively in hospitalised patients – the SAVE trial: study protocol for a multicentre randomised controlled trial. *BMJ Open* 2015; 5: doi:10.1136/bmjopen-2015-008689

11 Société Française d'Hygiène Hospitalière (SFHH), Haute Autorité de Santé. Prévention des infections liées aux cathéters veineux périphériques. Recommandations pour la pratique clinique [Prevention of peripheral venous catheter-related infections. Guidelines for clinical practice]. 2005. Available at: https://sf2h.net/wp-content/uploads/2005/11/SF2H_prevention-infections-catheters-veineux-peripheriques-2005.pdf [verified 23 October 2017].

12 Hadaway L. Short peripheral intravenous catheters and infections. *J Infus Nurs* 2012; 35: 230–40. doi:10.1097/NAN.0b013e31825af099

13 Becerra MB, Shirley D, Safdar N. Prevalence, risk factors, and outcomes of idle intravenous catheters: an integrative review. *Am J Infect Control* 2016; 44: e167–72. doi:10.1016/j.ajic.2016.03.073

14 Fields JM, Piela NE, Au AK, Ku BS. Risk factors associated with difficult venous access in adult ED patients. *Am J Emerg Med* 2014; 32: 1179–82. doi:10.1016/j.ajem.2014.07.008

15 Tuffaha HW, Rickard CM, Webster J, Marsh N, Gordon L, Wallis M, Scuffham P. Cost-effectiveness analysis of clinically indicated versus routine replacement of peripheral intravenous catheters. *Appl Health Econ Health Policy* 2014; 12: 51–8. doi:10.1007/s40258-013-0077-2

16 Australian Institute of Health and Welfare (AIHW). Australia's hospitals 2014–15 at a glance. Canberra: AIHW; 2016. Available at: https://www.aihw.gov.au/reports/hospitals/australias-hospitals-2014-15-at-a-glance/contents/admitted-patient-care [verified 23 August 2017].

17 Medicare Australia. Medicare item reports. Available at: http://medicarestatistics.humanservices.gov.au/statistics/mbs_item.jsp [verified 23 August 2017].

18 Ullman AJ, Marsh N, Mihala G, Cooke M, Rickard CM. Complications of central venous access devices: a systematic review. *Pediatrics* 2015; 136: e1331–44.

19 Helm RE, Klausner J, Klemperer J, Flint L, Huang E. Accepted but unacceptable: peripheral IV catheter failure. *J Infus Nurs* 2015; 38: 189–203. doi:10.1097/NAN.0000000000000100

20 Chopra V, Flanders SA, Saint S, Woller SC, O'Grady NP, Safdar N, Trerotola SO, Saran R, Moureau N, Wiseman S, Pittiruti M, Akl EA, Lee AY, Courey A, Swaminathan L, LeDonne J, Becker C, Krein SL, Bernstein SJ. Michigan Appropriateness Guide for Intravenous Catheters (MAGIC) Panel. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): results from a multispecialty panel using the RAND/UCLA appropriateness method. *Ann Intern Med* 2015; 163(Suppl): S1–40. doi:10.7326/M15-0744

21 Australian Institute of Health and Welfare (AIHW). Admitted patient care 2015–16: Australian hospital statistics. Canberra: AIHW; 2017. Available at: https://www.aihw.gov.au/reports/hospitals/ahs-2015-16-admitted-patient-care/contents/table-of-contents [verified 14 August 2018].