

The Costs of Running an Orthopaedic Theatre Per Hour at a Tertiary Hospital in South Africa

Schalk Klopper*, Nick Kruger

Division of Orthopaedics, Department of Surgery, Faculty of Medicine and Health Sciences, University of Cape Town, Cape Town, South Africa.

How to cite this paper: Schalk Klopper, Nick Kruger. (2023) The Costs of Running an Orthopaedic Theatre Per Hour at a Tertiary Hospital in South Africa. *International Journal of Clinical and Experimental Medicine Research*, 7(4), 557-566.
DOI: 10.26855/ijcemr.2023.10.007

Received: September 30, 2023

Accepted: October 29, 2023

Published: November 30, 2023

***Corresponding author:** Schalk Klopper, Division of Orthopaedics, Department of Surgery, Faculty of Medicine and Health Sciences, University of Cape Town, Cape Town, South Africa.

Abstract

Background: In South African Hospitals, orthopaedic departments have an increasing burden of trauma to manage with limited resources. Operating theatre availability is an expensive scarce commodity and needs to be well managed to cope with the demands of trauma. Orthopaedic surgical theatres are known to be associated with higher costs than other disciplines due to the complexity and duration of the surgeries as well, in addition to costly implants. The South African healthcare system is under great financial strain as government cuts in healthcare expenditure are enforced by the poorly performing economy, the ravages of COVID-19, and load-shedding. For these reasons, careful financial planning and budgeting are required to optimize efficient operating theatre usage, and establishing an accurate costing model is critical to achieving these goals. At present there is no established model for theatre costs in South Africa. This study aims to quantify the cost of running an orthopaedic theatre service at a tertiary-level government hospital to guide healthcare systems in economic decision-making. **Methodology:** Prospective Descriptive study where data Collection was performed in the orthopaedic theatre complex at Groote Schuur Hospital over two weeks in June 2017. Three theatres were audited over a total of 8 days over the two-week study period. The resources identified were consumables, medication, services, staff, medical gases, electricity, and water. In total 14 orthopaedic cases were observed. Information on the above usages from those surgeries was documented and raw data was collected. **Results:** In total, it was calculated that the cost of running the 3 theatres over the study period was R867 618.91, totaling R43 221.33 per hour. For individual theatres, the cost is thus R14 407.11 per hour (R240.11/min) per theatre (Excluding implants). Staff and human resources by far equated to the highest cost. A total of R86 7618.91 or R29917.89/hour was the calculated cost of staff over the study. period which was significantly higher than other expenses. Orthopaedic implants also ran a high cost at an average of R20 473.31 per case. Medical cases and anesthetic drugs were similarly expensive at R12 066.80 per hour. **Conclusion:** The cost of running orthopaedic theatres at a tertiary hospital is highly cost intensive at R43 221 per hour (2 500 USD/hour). Although there are limitations (small sample size over a short study period) it is an attempt at adding a monetary value to the cost of orthopaedic operating time in a state hospital, which has not been accurately quantified, not only in the literature but also on the management platforms around hospitals in South Africa. Understanding and identifying the cost of orthopaedic services is paramount. This will not only allow hospital management to manage resources more efficiently but also assist

in forming and structuring an economic model for private sector hospitals as well as a possible national health service.

Keywords

Theatre cost, surgery, orthopaedic surgery, health economics

1. Introduction

In South African Hospitals the orthopaedic departments deal with large workloads mainly due to the trauma burden which has reached epidemic proportions. The resources available are often restricted and need to be well managed, especially the operating theatre. Operating theatre is one of the major cost generators but also one of the major profit-generating entities in certain hospitals particularly in the private sector. Theatre time is of the essence to treat and process patients and its efficient usage is vital.

Hospitals and specific departments in hospitals have different reasons for assessing costs including concepts such as economic decision-making and resource management; justification for reimbursement and fair pricing; awareness of costs to encourage or discourage certain services e.g.; income and asset measurement regarding external parties and outsourcing and appropriate management of resources [1].

At present, there is no established model for theatre costs in South Africa [2]. It is our goal in this study to establish the costs per hour of running an orthopaedic theatre at a tertiary-level hospital.

It has been shown that orthopaedic procedures are associated with higher costs than other surgical specialties [3], largely due to the nature of the procedures performed and the vast number of resources, implants, and consumables needed to deliver an orthopaedic service safely and efficiently.

South Africa's healthcare system and financial structures have significant cost constraints due to a struggling economy and careful planning and budgeting need to be implemented to ensure the efficient distribution of funds. Unfortunately, this is not always the case and poor planning leads to irrational expenditures and dispersion of funds [4-6].

Theatre operating costs are substantial with expensive equipment, human resources, and running costs. In a paper from the West Indies, the cost of running 4 operating theatres per day was US \$6 242 in 2006, and \$8 873 in 2009 [7]. This equates to \$2218 per theatre per day (R22 847.98 per theatre per day based on the average 2009 R/\$ exchange rate) and thus R2855.99 per hour. In the same paper, the cost of wasted theatre time was estimated at US \$298 342 in 2006 per year.

Protocols and algorithms in theatre to prevent complications and optimize efficient time usage have resulted in considerable savings [8], emphasizing the well-known expression that "time is money".

Childers et al. estimated that the average cost of operating theatre time is US \$36 to \$37 per minute [3] (around R479 to 492 based on the average USD to ZAR at the time of this study).

In a South African study, it was found that South African private hospitals have a 48% theatre utilization efficiency, which when compared to international statistics (70-80%) was significantly lower [9].

Another South African paper by Asmal et al looked at the inefficient use of theatre time about starting times and theatre turnaround time and found a significant amount of time inefficiency in the theatre complexes observed, with financial cost implications [10]. This highlights the importance of understanding efficiency in theatre and the effectiveness of audits.

Awareness of costs and responsible use of resources can help effect cost savings in the operating theatre setting [7, 11], mainly because staff are often unaware of costs relating to the equipment and consumables they are using. As a result, cost awareness programs and education are strongly recommended [12, 13], particularly in orthopaedic theatres, with costly equipment and consumables. Understanding the true costs of running a theatre service is essential to manage theatre efficiently and optimizing the available funding to maintain an orthopaedic service.

2. Study Objectives

The aim of this project was to identify the resources and services required to run an orthopaedic theatre at a South African Tertiary Hospital and calculate the cost of running the theatre complex per hour.

3. Methods

Different factors regarding the cost of running the orthopaedic theatre complex theatre were identified and quantified.

Study Design: Prospective Descriptive

Data Collection was performed by medical students from the University of Cape Town at the Groote Schuur Hospital D10 orthopaedic theatre over a two-week period in June 2017. The theatres included in the study functioned from Monday to Thursday each week thus amounting to 8 days in total. Three theatres were included.

Students were allocated to each of the 3 theatres in the dedicated orthopaedic theatre complex, and each given the task of collecting varying data. The resources identified were consumables, medication, services, staff, medical gases, electricity, and water.

In total, 14 orthopaedic cases were observed. Information of the above usages from those surgeries were documented and raw data was collected.

4. Data Collection and Calculation

4.1 Consumables

Anaesthetic consumables used to administer drugs were documented for each case and done for the duration of each surgery.

Medical masks and gloves used by theatre staff were documented and counted and mask or glove type documented.

The number of surgical boots worn by the medical health professionals was counted – non-disposable boots (such as gumboots) were ignored.

Disposable surgical caps were counted, with the non-disposable caps being ignored

Other resources such as intravenous fluids, and swabs (alcohol, gauze, LDS, paediatric, and abdominal) were physically counted for each of the 14 cases. With the assistance of the scrub nurses who were in the theatre each time data was being collected, a total of 66 consumables were identified and counted over the 2 weeks for 14 cases.

A formal document from the hospital finance department was made available that listed the above-mentioned consumables and the unit price for each. The consumables that were not present on the list were researched and their local prices were collected from the internet and an average price was calculated for each item.

4.2 Implants

Orthopaedic implant costs were not included in this study to obtain a more consistent costing, which would be more applicable to a generic government hospital, rather than reflect the implant usage in a tertiary-level hospital with a vastly different patient profile. The implant costs however have been calculated at an average cost to emphasise the added expenses above theatre costs.

4.3 Medical Gases

The medical gases that were accounted for consisted of oxygen and nitrous oxide. Volatile anaesthetic gasses were also taken into account and measured.

The volume of oxygen that was administered to the patient was displayed on the continuous-flow anaesthetic machine and the total amount of gas administered to the patients was calculated.

The price per cylinder of oxygen and per cylinder of nitrous oxide was obtained from the tendered trading company Afrox after communication with the sales call centre.

The amount of isoflurane and sevoflurane administered to each patient during the 14 cases was displayed on the continuous-flow anaesthetic machine and similarly the total amount of anesthetic gas delivered to each patient and the cost was calculated.

4.4 Medication

The different medications administered to patients during the 14 cases were recorded after the patient was released from theatre and moved to the recovery ward.

Medication costs were made available by the hospital pharmacy at Groote Schuur Hospital. This document was obtained after direct communication with the pharmacy department.

This amount added up to R10 317.39.

4.5 Services

The services identified were electricity, water, telecommunications, and laundry services.

4.6 Electricity

The amount of electricity used in a month was calculated by measuring the total voltage usage. The total number of volts used in a day was measured from the theatre's power box. The power box was divided into a normal supply and an emergency supply. With help from an electrical engineer, it was possible to measure the voltage for each supply, and an average from these 6 portions was calculated. Since electricity is measured in Watts, the voltage was converted to Watts using the Power formula ($P = IV$). The current (I) was 220-230 Amp.

With the total power calculated in an hour (kWh), the amount of money spent on electricity was calculated by multiplying the total amount of electricity used in an hour by the electricity tariff (i.e., R2.34).

Water usage was calculated by recording the amount of time water was running from a tap used in the theatre. Water usage was calculated before during and after surgery.

An average flow rate for 1 liter was calculated and applied to the water usage time to give the total amount of water used.

The water used to flush the toilets in the theatre changeroom was also accounted for. The average amount of toilet flushes per hour was recorded and multiplied by the average volume of water used per toilet (5 litres).

The total number of liters obtained from the 2 weeks was multiplied by the water tariff @R142/kilolitre.

4.7 Telecommunication

The telephone usage was equated to the total number of hours spent in theatre (29.2 hours).

The telephone bill was made available to the group by the hospital for the period of the study.

4.8 Laundry Services

The quantity of laundry produced during the 14 cases was physically counted from the laundry baskets post theatre episode.

The price of each unit of laundry was obtained from the cleaning department of the hospital following a direct request.

4.9 Staff and Human Resources

The total number of staff involved and present during the 14 cases was counted and the different job designations and salary levels were documented.

The salaries of the various staff members present in the theatre during a theatre episode were made available by the Human Resources department of the hospital after request.

5. Results

From the data collected costs could be calculated as follows.

Services including electricity, water, and laundry cost a total of R5 527,01 throughout the study which equates to R190.58 per hour (see Table 1). Telephone costs were minimal costing R3.88 per hour with most calls being internal calls adding up to R188.57 over 29 hours. These services were quantified and had standardized pricing and thus simpler to calculate.

Staff and human resources by far equated to the highest cost to running the 3 theatres. A total of R86 7618.91 or R29917.89/hour was the calculated cost of staff over the study period (see Table 2). This is a significant amount in comparison to other expenses and one needs to consider that the study was done at a teaching hospital. Adequate staffing is essential to run any theatre but at an academic hospital there are often multiple parties involved in theatre cases for teaching and learning purposes, which could account for increased staffing costs.

Medical gases proved to be another noteworthy expense with oxygen and nitrogen costing R157159 (R5419.27/h) and R179637(R6194.37/h) respectively over the 29hour study period. (see table 4)

Anaesthetic drugs and other medication amounted to R10 317.39. Volatile anaesthetics were calculated at R2823.89 over the course of the study (R97.37/h).

Consumables were calculated to cost R1042.18 per hour. This is an average and it can be expected that certain cases would require more consumables than others (see Table 5 for a breakdown of consumable costs).

In total, it was calculated that the cost of running the 3 theatres over the study period was R867 618.91, totaling R43221.33 per hour. For individual theatres, the cost is thus R14 407.11 per hour (R240.11/min) per theatre.

Table 1. The costs of services: electricity, laundry and water for the total time spent in theatre

Cost Determines	Quantity	Units	Unit Cost (R)	Total Cost (R) IN 29 H
ELECTRICITY	1244.93	kw/h	2.34	2913.14
LAUNDRY	507	scrubs/linen	3.19	1617.33
WATER	6.99	kilo litres	142.47	996.54

Table 2. Staff Members and Salaries (per hour) at Time of Surgery

Cost Determines	Quantity	Unit Cost (R)	Total Cost (R) IN 29 HRS
HUMAN RESOURCES			
Clinical manager	1	458.33	13291.67
ADMIN clerk	1	26.04	755.16
CLINICAL TECHNOLOGIST	1	148.98	4320.42
CLIN TECHNOLOGIST chief	2	230.51	13369.58
OP MAN Nurse	1	84.27	2443.83
Surgeon Consultant	17	448.89	221 302.77
Anaesthetist Consultant	14	600.09	243636.54
Surgeon Registrar	23	390.55	260496.85
Intern	3	213.76	18597.12
Anaesthetist Registrar	12	381.28	132685.44
Radiographer	6	160.53	27932.22
Scrub nurse	14	95.20	38651.20
Floor nurse	14	73.25	29739.50
Anaesthetic nurse	14	73.25	29739.50
Porter	14	52.20	21193.20
Cleaners	21	50.52	30766.68

Table 3. Cost of medical gases for total time spent in theatre

Cost Determines	Quantity	Units	Unit Cost (R)	Total Cost (R) IN 29 HRS
GASES				
Oxygen	1675.29	L	93.81	157159
nitrous oxide	605.90	L	296.48	179637

Table 4. Cost of volatile anaesthetics and drugs administered to patients

Cost Determines	Quantity	Units	Unit Cost (R)	Total Cost (R) IN 29 HRS
Drug				
isoflurane	8	250ml	238,34	1906,72
sevoflurane	1	250ml	917,17	917,17
Pharmaceutical <u>drugs</u>	<u>1</u>	<u>total</u>	10317.39	<u>10317.39</u>

Table 5. Cost of consumables used over 29 hours spent in theatre

Cost Determines	Quantity	Units	Unit Cost (R)	Total Cost (R) IN 29 HRS
CONSUMABLES				
Sterile Gloves nitrile	26	pair	5,52	143,52
Sterile gloves latex	32	pair	4,8	153,6
Non-sterile gloves	132	each	0,5883	77,65
Visor shield mask	28	each	3,0998	86,79
Normal surgical mask	141	each	1,9896	280,53
surgical shoe covers	96	pair	0,82	78,72
surgical caps blue	95	each	0.23	21.85
surgical caps green	3	each	0.34	1.02
mayo table covers	28	each	39,17	1096,76
ECG electrodes	42	each	44,27	1859,34
1 l saline water	14	1000ml	11,91	166,74
1 l sterile water	24	1000ml	10,21	245,04
Skin stapler	4	each	32,74	130,96
Suture material	51	each	20,91	1066,75
IV-infusion lines	11	each	359	3949
Disposable Yankauer suction	14	each	6,88	96,32
Suction tubing	17	each	160,44	2727,48

3m loban sling wrap	10	3m each	2269	22690
Voluven	2	500ml	59,63	119,26
Ringer's lactate	14	1000ml	11,91	166,74
drip sets	14	each	16,36	229,04
specimen jar	1	each	4,28	4,28
disposable surgical gown	7	each	1426,88	9988,16
Isopropyl alcohol swabs	115	each	0,87	100,05
Sterile gauze swabs	185	each	3,86	714,1
Abdominal swabs	11	pack of 5	33,14	364,54
paediatric swabs	5	pack of 5s	33,2	166
Non sterile swabs	13	pack of 5	18,56	241,28
chlorhexine gluconate 0.5 %	6	500ml	14,47	86,82
primapore dressing large	11	Each	2,59	28,49
primapore dressing medium	2	Each	1,49	2,98
Band plaster adhesive	2	Each	27,51	55,02
Patient warmer air blanket	11	Each	200	2200
bandage tubul	1	Each	80,03	80,03
skin pen marker	11	Each	41,04	451,44
gypsona 75mm roll	8	Each	24,11	192,88
spinal needles	2	each	41	82
18G needles	28	each	2,61	73,34
Syringes	83	each	0,75	62,25
50 ml syringes	5	each	4,05	20,25
leukosan strips	3	12 pack	3,26	9,78
cotton wool	5	rolls	25,56	127,8
Elastoform 150mm bandage rolls	6	each	9,88	59,28
Surgical blades	23	each	252,22	5801,06
Arterial line	14	each	143,64	2010,96
intravenous cannula	14	each	8,23	115,22
occlusive dressing	14	E ach	13,99	195,86
Red medical waste bags	13	each	4,67	60,71
medium disposal bags	22	each	1,95	42,9
Aprons yellow	14	each	1,37	19,18
Aprons white	9	each	2,3	20,7

sterile pack/ dressing tray	14	each	7,29	102,06
¼ inch surgical drain	1	each	55,96	55,96
bloomberg abduction sling	1	each	55,6	55,6
Medical waste bag large	15	each	1,59	23,85
scrub brushes	65	each	4,65	302,25
Clorhexidine scrubbing disinfectant	3	500ml bottles	25,20	75,60
Clorhexidine hand sanitiser	2	500ml bottle	15,85	31,70
cleaning equipment disinfectant	5	500ml bottles	200	1000
toilet soap 750ml	4	each	13,5	54
disposable sheets	13	each	12,95	168,35
disposable pillow covers	11	each	137,6	1513,6
sterile drapes	4	each	37,7	150,8
toilet rolls in bathrooms	16	rolls	2,01	32,16
soda lime	5	5kg	280,09	1400,45

Table 6. Total amount spent in theatre D10 over 29 hours and Cost per 1 hour

	IN 29 HRS (R)	IN 1 HR (R)
Electricity	2913.14	100.45
Water	996.54	34.36
Laundry	1617.33	55.77
Consumables	30223.15	1042.18
Medical gases and Volatiles	339619.89	11711.03
Pharmaceutical drugs	10317.39	355.77
Telephone	112.46	3.88
Human Resources(staff)	867618.91	29917.89
TOTAL	1253418.81	43 221.33

6. Limitations

Data was only collected over the course of 2 weeks excluding after-hours theatre time. This also only included 4 days a week, thus a longer study period would have increased the validity of the results and accuracy of costs.

The list of medicine was not up to date and could have been subject to change.

With regards to the gases, the initial mass of the cylinder was unknown thus the total mass was taken to be that of the gas. Flow was calculated as best possible using anaesthetic machines but could not account for all gas flow used.

During the study certain consumables were identified late and not included in study which could result in higher costs than predicted.

The costs calculated were for 3 theatres in a complex and not individually calculated per theatre or subspecialty.

7. Discussion

From this study, the cost of running orthopaedic theaters in a tertiary hospital, amounts to R43221.33 (USD

\$3248.38) per hour in 2017. Which with adjusted inflation would amount to R55890.55 in 2023 based on an annual inflation increase of 5.3% (total 29.3). This amounts to R720.35 per minute or R240.11/min on average for a single theatre. These per-minute costs do not completely correlate with other published cost estimates although there are some similarities [1, 3]. Different study designs and variables influence cost estimates, often preventing direct comparisons, and not all costs can be completely accounted for in an operating theatre, with unforeseen variables and unaccounted items. The cost of orthopaedic operating time in a state hospital has not been accurately quantified, not only in the literature but also on the management platforms around hospitals in South Africa. This study strived for the first time, to assign a monetary value to a very complex process which has not been done previously in South Africa. The costs were an average of expenses over the study period and are likely underestimating the true costs of running theatre, which are unavoidable expenses applicable to most theatres across Africa and the world.

Implants are a major expense and the cost of orthopaedic implants ranges vastly depending on the nature of the implant and subspecialty. Some subspecialties such as tumour and reconstruction, and spinal deformity surgeries cost significantly more than other operations such as simple long bone fixation. On average implant costs for orthopaedic procedures were R20 473.31 per case in 2017 based on an audit of 6 months of surgeries and their implant costs obtained from the government implant tender document. This amounts to R6824.44 per hour based on the average cases done per day at Groote Schuur Hospital D10 orthopaedic theatre over 1 year divided into an 8-hour theatre day. This alone adds an enormous cost to the orthopaedic service delivery but was not included in the study. Because there is such great variation in the management of various orthopaedic conditions, depending on local skills and implant budgets, implants are probably the least consistent variable in theatre cost generation and would render our cost analysis poorly applicable to other hospitals with differing skill sets and patient populations. An example would be the treatment of a neck or femur fracture with a simple uncemented hemi-arthroplasty or donated implants, vs a tertiary level hospital which may choose a third-generation total hip replacement implant resulting in a huge cost difference. Future studies including multi-center analysis of average implant costs are required to truly appreciate the vast sums of money spent on orthopaedic services.

8. Conclusion

It is clear from our study that human resources were by far the most expensive aspect of running a theatre and proper management of staff and regulation of working hours are essential in cost efficiency.

Further studies should include costing at various hospitals to account for local variations in expenditure due to different surgeon skill sets, subspecialties, and patient demographics. Potentially building on this study and creating a strict prospective auditing system to account for consumables as well as standardizing measurements more efficiently could prove to give a more accurate result in the future. A longer study period would also statistically provide higher quality data and allow for scrutiny of expenses and recognition of expenditure trends.

This will not only allow hospital management to manage resources more efficiently but also assist in forming and structuring an economic model for private sector hospitals as well as a possible national health service.

References

- [1] Macario A. What does one minute of operating room time cost? *J Clin Anesth* 2010; 22(4):233-236. <https://doi.org/10.1016/j.jclinane.2010.02.003>.
- [2] SAMUEL, J P; REED, A. The costing of operating theatre time in a secondary-level state sector hospital: A quantitative observational study. *South African Medical Journal*, [S.l.], v. 111, n. 6, p. 595-600, May. 2021. ISSN 2078-5135.
- [3] Martin, C., Thiart, G., McCollum, G., Roche, S., Maqungu, S. 2017. The burden of gunshot injuries on orthopaedic healthcare resources in South Africa. *South African Medical Journal*. 107(7).
- [4] Childers CP, Maggard-Gibbons M. Understanding Costs of Care in the Operating Room. *JAMA Surg*. 2018; 153(4):e176233. doi:10.1001/jamasurg.2017.6233.
- [5] Ang WW, Sabharwal S, Johannsson H, Bhattacharya R, Gupte CM. The cost of trauma operating theatre inefficiency. *Ann Med Surg (Lond)*. 2016 Mar 5; 7:24-9. doi: 10.1016/j.amsu.2016.03.001. PMID: 27047660; PMCID: PMC4796663.
- [6] Kabeer M, Okoli A, Ahmad N. Counting the cost of high priced consumables used in theatre. *Br J Hosp Med (Lond)*. 2016 May;77(5):312. doi: 10.12968/hmed.2016.77.5.312. PMID: 27166114.
- [7] Hariharan S, Chen D. Costs and Utilization of Operating Rooms in a Public Hospital in Trinidad, West Indies. *Perm J*. 2015;19(4):e128-e132. doi:10.7812/tpp/14-183.
- [8] Volpin A, Khan O, Haddad FS. Theater Cost Is £16/Minute So What Are You Doing Just Standing There? *J Arthroplasty*. 2016

Jan;31(1):22-6. doi: 10.1016/j.arth.2015.08.008. Epub 2015 Aug 14. PMID: 26350259.

- [9] Hartmann D, Sunjka B. Private theatre utilisation in South Africa: a case study. *S Afr Med J*. 2013 May;103(5):285-7. doi: 10.7196/samj.6460. PMID: 23971113.
- [10] Asmal II, Keerath K, Cronjé L. An audit of operating theatre utilisation and day-of-surgery cancellations at a regional hospital in the Durban metropole. *S Afr Med J*. 2019 Sep 30;109(10):765-770. doi: 10.7196/SAMJ.2019.v109i10.13815. PMID: 31635575.
- [11] Tseng J, Sax HC, Gewertz BL, Margulies DR, Alban RF. Surgical Supply Cost Awareness Is Associated With Lower Costs: A Single-Center Experience. *Am Surg*. 2020 Oct;86(10):1407-1410. doi: 10.1177/0003134820964494. Epub 2020 Oct 25. PMID: 33103463.
- [12] Hardy A, Yick JWJ, Tucker P, Ferguson N. Hospital staff awareness of operating theatre supply cost in a regional centre. *Aust J Rural Health*. 2020 Feb;28(1):87-88. doi: 10.1111/ajr.12582. Epub 2020 Jan 16. PMID: 31950577.
- [13] Glennie RA, Barry SP, Alant J, Christie S, Oxner WM. Will cost transparency in the operating theatre cause surgeons to change their practice? *J Clin Neurosci*. 2019 Feb;60:1-6. doi: 10.1016/j.jocn.2018.09.024. Epub 2018 Oct 26. PMID: 30626523.