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HEALTH SCIENCES
GESONDHEIDSWETENSKAPPE

8 January 2019

To whom it may concern

RE: Cost analysis of violence-related medical imaging in a Free State tertiary trauma unit – Tiaan P. Steyn

As supervisor of the research undertaken by Dr TP Steyn in fulfilment of the requirements in respect of the Master's Degree MMed in the Department of Clinical Imaging Sciences in the Faculty of Health Sciences at the University of the Free State, I approve the submission of this work for assessment.

To the best of my knowledge this published article titled *Cost analysis of violence-related medical imaging in a Free State tertiary trauma unit* has not previously, either in part or its entirety, been submitted to the examiners for assessment.

Yours sincerely

Dr Fekade A Gebremariam
Doctor of Medicine (Addis Ababa University), FC Rad Diag (SA).
Head of Department, Consultant Radiologist
Department Clinical Imaging Science
University of the Free State

COST ANALYSIS OF VIOLENCE-RELATED MEDICAL IMAGING IN A FREE STATE TERTIARY TRAUMA UNIT

by

Tiaan Pieter STEYN

Submitted in fulfilment of the requirements in respect of the Master's Degree M. Med in the Department of Clinical Imaging Sciences in the Faculty of Health Sciences at the University of the Free State

8 January 2019

Supervisor:

Dr. F.A. Gebremariam

I, Tiaan Pieter STEYN, declare that the coursework Master's Degree mini-dissertation that I herewith submit as a published article for the Master's Degree qualification M. Med (Diagnostic Radiology) at the University of the Free State is my independent work and that I have not previously submitted it for a qualification at another institution of higher education.

Authors' contributions:

- Tiaan Steyn was the principal investigator who conceptualised and designed the study, conducted the literature review, obtained ethical clearance from the relevant ethical committees, captured the data, processed the data and wrote the final manuscript.
- Fekade Gebremariam was the study leader, assisted with designing the study, literature review, critically evaluated the manuscript and approved the final version.

Acknowledgements:

The authors would like to thank Cornel van Rooyen from the Department of Biostatistics, University of the Free State, for his assistance in the statistical analysis of the data as well as Geranda Opperman for her assistance in ensuring the data integrity of the initial database.

Abstract:

Background:

Violence is a leading public health problem worldwide. Beyond the pain and suffering, violence has a significant economic impact on a country's health, policing, and judicial services. Due to the lack of current and comprehensive data in South Africa, local violence-related economic impact studies are largely estimations. Violence-related imaging expenditure, as a component of a public hospital's expenditure, is yet to be determined.

Objectives:

To measure the violence-related patient burden on Pelonomi Tertiary Hospital's (PTH) trauma and radiology services, determine the imaging-component cost of violence-related injuries and calculate the financial burden violence has on the hospital's expenditures.

Method:

From the PTH's Trauma Unit patient registry, 1 380 patients with violence-related injuries were consecutively sampled for six months ending 31 December 2017. Imaging investigations were documented and categorised according to the South African National Department of Health's (SANDOH) 2017 Uniform Patient Fee Schedule (UPFS). Descriptive analysis and cost calculations were performed using the 2017 UPFS tariff schedule and hospital-specific health efficiency indicators i.e. Patient Day Equivalent (PDE) and Expenditure per Patient Day Equivalent (ExPDE).

Results:

Violence-related injuries accounted for 50.64% of all trauma department visits and received a total of 5 475 imaging investigations. Violence-related imaging investigations represented 14.81% of all investigations performed by the radiology department in the study period. Overall violence-related admission costs amounted to R35 410 241.85 (8.33% of the hospital's total expenditure) of which 20.08% (R7 108 845.00) was attributed to imaging investigations.

Conclusion:

Violence-related admissions had a high patient and financial burden on PTH. The pinnacle of health care cost saving is violence prevention; however, the cost-conscious radiologist could assist with cost saving if responsible and ethical imaging practices are followed.

Keywords:

Violence; Trauma; Imaging; Radiology; Expenditure; Cost analysis

Introduction:

In 2008, violence was earmarked as the leading cause of death (31.5%) among 31 177 unnatural deaths recorded in the National Injury Mortality Surveillance System report of South Africa. However, it was already in 1996 at the Geneva World Health Assembly that violence was declared a leading worldwide public health problem.[1]

Locally, the South African Police Service precincts in and around Bloemfontein reported a total of 8 101 crimes in the categories of attempted murder, assault with the intent to inflict grievous bodily harm, common assault and robbery with aggravating circumstances. This was for the period 1 April 2017 to 31 March 2018.[2]

Beyond the pain and suffering caused, violence has a significant economic impact on society, both directly and indirectly. Some of the direct costs include those borne by the victim and perpetrator as a result of the violence, loss of productivity at work, government expenditure relating to the health care, policing- and judicial services.[3–7]

Due to a lack of comprehensive data in South Africa, local cost-analysis studies can only estimate the economic impact of violence.[8] The provincial Departments of Health showed the second highest expenditure of all government departments, spending close to R150 billion in the 2015/2016 fiscal year. This translated to an average cost of R3 332 per person using public health care services in South Africa.[9–11] This is an extremely high burden on both the national and provincial governments' budgets when taking into consideration that, in 2014, health care contributed close to nine percent of South Africa's Gross Domestic Product.[12]

Health information (e.g. cost analysis studies) is crucial in the planning, implementation, evaluation and management of health care resources, seeing that 82% of the South African population rely on the public health care system.[10,13–16]

There are limited studies in the South African literature that specifically focuses on the cost of medical imaging in violence-related injuries. Imaging investigations are expensive and the South African Competition Commission's Health Market Inquiry found that medical aid claims

relating to imaging investigations increased by an average of 10.98% per year between 2011 and 2014.[17]

The objective of this study was two-fold. Firstly, to determine the violence-related patient burden on trauma and radiology services at PTH, and secondly, to determine the cost of violence-related medical imaging and contextualising this cost in terms of PTH's total expenditure.

Research methods and design:

Study design:

This study was a descriptive cost analysis which aimed to measure the cost of violence-related medical imaging in the setting of a tertiary level public hospital. Due to the complexity of cost analysis studies, the most practical method for estimating this cost was to use the SANDOH's 2017 Uniform Patient Fee Schedule (UPFS). The UPFS is a fee schedule used to bill patients using public health care facilities and is applicable to externally funded patients using public hospitals in all provinces throughout South Africa.

Therefore, the study could more accurately be defined as a descriptive cost analysis using the theoretical maximum cost that can be charged by the hospital for medical imaging. Although the data might not reflect the exact cost of performing the imaging investigations, it does provide an estimation thereof.

According to the UPFS, all imaging investigations are categorised from category A to category E according to the complexity of the investigation. Furthermore, each category consists of two fixed prices: A facility fee (depending on the service level of the hospital) and a professional fee (depending on the training level of the health care practitioner who interprets the imaging investigation). The 2017 UPFS imaging fees are presented in Table 1.[18]

Research setting and sampling method:

The PTH's Trauma Unit served as the study population. This unit provides emergency medical care to the whole of central South Africa (Free State and parts of the Northern- and Eastern Cape) and keeps a detailed electronic patient registry including the diagnosis/mechanisms of

injury. Due to resource constraints and a high turnover of patients in the trauma unit, violence-related injuries for a 6-month period (1 July 2017 to 31 December 2017), were selectively used to ensure a manageable sample size.

Consecutive sampling was used to retrospectively select patients from the Trauma Unit's patient registry. Inclusion criteria consisted of patients of any age who were attended to in the above-mentioned period and who sustained violence-related injuries in the subgroups of 'penetrating assaults', 'blunt assaults', 'combination of blunt- and penetrating assaults' or 'gunshot injuries'.

Accidental- and self-inflicted injuries were excluded, as well patients who were dead on arrival. Patients who did not receive any imaging were excluded from cost calculations. Double registry entries and registry entries with missing data, which could not be recovered from the Hospital Information System, were also excluded.

Data collection:

The Trauma Unit's electronic database (Microsoft Excel Format) was filtered according to the inclusion and exclusion criteria. Each entry in the filtered database was manually cross referenced with the Hospital Information System (to eliminate database errors) and to obtain each patient's discharge date. Hereafter, all directly identifiable patient information (name, surname, identity number) were removed from the database to ensure patient confidentiality. Patients were only identified with their hospital numbers.

Hospital numbers and admission dates were cross referenced with the Picture Archiving and Communication System (PACS). Each individual examination performed during the patient's first admission was documented under the relevant modality and UPFS category A to E (using the UPFS procedure book). The procedure book contains more than 800 individual radiological investigations and procedures, and for this reason, investigations were not further subcategorised. Examinations were categorised from A – E and priced according to UPFS service level 3 facility fees and UPFS specialist professional fees.

The final database contained the number of imaging investigations performed for each patient categorised under the different imaging modalities and UPFS pricing categories.

Data analysis:

Descriptive statistics were calculated for continuous data and frequencies and percentages were calculated for categorical data.

Arithmetic- and cost calculations, incorporating the 2017 UPFS tariffs as well as health care efficiency indicators and relevant hospital expenses for the study period (obtained from the hospital's Information Unit), were used to calculate relevant imaging costs and proportionality between imaging costs and hospital expenditure.

Limitations:

Imaging investigations performed outside the radiology department e.g. fluoroscopy in theatre and eFAST ultrasounds in the trauma unit, are not uploaded to the PACS, and were subsequently not included in the study. This could have led to an underestimation in the total cost of imaging.

Contrast agents administered during the imaging investigations were not included in the cost analysis due to varying cost between the different brands as well as poor documentation of the exact amount and type of contrast that was administered.

Patients seen at PTH's casualty department (separately functioning department from the trauma unit) were not included in the study – this was due to the lack of an electronic patient registry.

Results:

A total of 4 966 patients were treated at PTH's trauma unit in 2017 of which 2 725 patients were treated during the period 1 July 2017 to 31 December 2017. Within this period, 1 380 patients matched the inclusion and exclusion criteria. Violence-related injuries constituted 50.64% of all trauma department visits during the study period. Descriptive statistics are summarised in Table 2.

The sample of 1 380 patients included 1 228 males (mean age of 31.22 years) and 152 females (mean age of 32.71 years). The study sample's injuries consisted of 53.77% penetrating injuries, 37.46% blunt injuries, 2.46% combination injuries and 6.3% gunshot injuries. A combined 5 475 individual imaging investigations were performed on 1 273 patients in the study sample. A total of 107 patients did not receive any imaging and were excluded from further cost calculations.

General X-rays represented the bulk of the imaging investigations totalling 3 834 investigations and amounted to R843 354.00. Computed Tomography (CT) scans totalled 1 566 investigations, however, contributed to the highest cost of R5 957 280.00. A detailed breakdown of imaging cost per imaging modality are presented in Table 3. A total of 5 475 imaging investigations amounted to R7 108 845.00 of which R2 631 939.00 represented level 3 hospital facility fees and R4 476 906.00 the specialist professional fees.

The average cost of imaging investigations for the different injury types are presented in Table 4.

From the patient sample, 978 patients (70.87%) were admitted to hospital with a combined total of 9 221 admission days. Patients who were not admitted to hospital totalled 295.

Discussion:

Although the Uniform Patient Fee Schedule (UPFS) applies to externally funded patients being treated in a public hospital, it should be noted that all state patients are billed according to the UPFS tariffs. The UPFS tariffs applicable to imaging investigations are used by public hospitals to incorporate the cost of imaging into performance indicators as well as used for financial analyses and budgeting.

After the invoicing is done, a patient may qualify for a rebate. The percentage rebate is dependent on the income level of the patient and other factors. Rebates may be up to 100% in H0 classified patients (pensioners and formally unemployed patients) and 0% in H3 patients (therefore full paying patients). Where rebates apply, the rebates are covered by the hospital. Aspects such as actual patient invoicing, debt collection and the reconciliation thereof are beyond the scope of the study. Instead, the study used the theoretical maximum that could be charged to patients for medical imaging received in a tertiary government hospital i.e. no rebates were considered. Therefore, if all patients in the study sample were regarded as H0 classified patients, the total invoice for imaging services would have had to be covered by the hospital.

The billing total of imaging performed in the study sample was R7 108 845.00. This includes both the professional fees and the facility fees as set out in the UPFS. This billing total is an underestimation of the true amount due to the previously stated limitations.

In the study sample, general X-rays were the most frequently performed investigation (n = 3 834) and contributed 11.9% to the total imaging bill, whereas CT scans (n = 1 566) contributed 83.8% (R5 957 280.00) to the total bill. The modality with the third highest cost was Magnetic Resonance Imaging (MRI) (n = 38) totalling R271 510.00, followed by Ultrasound (n = 21) and Fluoroscopy (n = 16) which totalled R14 109.00 and R22 592.00 respectively. In perspective, for every R1.00 the hospital billed for imaging in violence-related injuries, 84c was for CT scans, 12c for X-rays and 4c for MRI. The cost of ultrasound- and fluoroscopic investigations were negligible, because records pertaining to ultrasounds performed by trauma personnel and screening procedures performed in theatre, were not available for analysis.

Medical imaging, as a component of in-hospital services and costs, can be put into perspective by determining the patient burden on radiology services as well as what share it holds in the hospital's total expenditure. The radiology department performed a total of 36 956 imaging investigations in the study period. Violence-related imaging investigations, referred from the trauma unit, constituted 14.81% of all these investigations, however, this is an underestimation due to the study limitations and considering that none of the casualty department's violence-related imaging referrals were included in the study.

To put the imaging costs into perspective, comparison to the hospital's overall expenditure is needed. This can be done by comparing the data to the hospital's Expenditure per Patient Day Equivalent (ExPDE). ExPDE is widely used as a proxy for a hospital's cost-effectiveness and is calculated by dividing the hospital's total expenditure by the hospital's Patient Day Equivalent (PDE). A single PDE is a unit which can represent one or more patient depending on the hospital resources the patient or patients consume in a 24-hour period. This is calculated by using all inpatient days, half of out-patient visits and a third of emergency department visits. The rationale behind the formula is that out-patient visits and emergency department visits are estimated to consume one half and one third, respectively, of the resources spent on a single 24-hour patient admission. Therefore, ExPDE represents the average cost per patient per 24-hour services rendered by the hospital.[19] Before comparing the data to the hospital's ExPDE, an "Imaging Expenditure per Patient Day Equivalent" was calculated in accordance with the ExPDE formula. This provided an average imaging cost per PDE for the study sample.

The study sample included 978 patient hospital admissions with a total of 9 221 admission days. This represented 9 221 PDEs. One third of the remaining non-admission patients represented 98 PDEs which led to a total of 9 319 PDEs in the study sample. Dividing the total imaging cost with the sample's PDE amounted to an Imaging ExPDE of R762.83. Thus, the average cost of imaging per violence-related admission day was R762.83. Calculations are summarised in Table 5.

Calculated from PTH's financials for the study period, irrespective of the admitting department, the average cost per patient per 24-hours (ExPDE) was R3 799.79. When the study sample was compared to the hospital's ExPDE, violence-related imaging was found to constitute 20.08% of the hospital's average cost per patient per 24-hour admission.

Consequently, this proved that a considerable portion of money was spent on medical imaging in violence-related hospital admissions.

Using PTH's ExPDE and the study sample's PDEs, the hospital spent a total of R35 410 241.85 on violence-related trauma admissions for the last six months of 2017. This translated to 8.33% of the hospital's total expenditure of R424 898 583.55 for this period. Seeing that violence is unlikely to disappear in the foreseeable future, all role players in the management chain of violence-related hospital admissions should be cost-conscious and avoid unnecessary expenditure.

Violence and its associated injuries are closely related, therefore, similar studies at set intervals may not only prove useful as cost analysis studies, but also prove as useful indicators of the incidence of violence, the financial burden on health care services as well as the effectiveness of existing violence prevention strategies and campaigns.

Conclusion:

Violence often lead to injury and the need for health care. During the last 6 months of 2017, 92.2% (n = 1 273) of violence-related trauma department visits to PTH received imaging. The radiology department, therefore, plays an important role in the management chain of violence-related injuries. Violence-related admissions from the trauma unit cost PTH R35 410 241.85 in the last six months of 2017. An underestimated 20.08% of this expenditure was attributable to imaging investigations. Although we, as radiologists, can't prevent violence at ground level, the services we provide constitute a significant portion of violence-related health care cost. In South Africa, with regular budget shortages, a recently announced technical recession, and the anticipated implementation of National Health Insurance, the need for cost-saving strategies are becoming ever more important.

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Tables:

Table 1: 2017 Uniform Patient Fee Schedule imaging tariffs.

Category of Investigation	Professional Fee	Facility fee		
		Level 1	Level 2	Level 3[a]
Category A		R72.00	R72.00	R80.00
Allied Health Practitioner	R69.00	R141.00	R141.00	R149.00
General Medical Practitioner	R70.00	R142.00	R142.00	R150.00
Specialist Medical Practitioner	R131.00	R203.00	R203.00	**R211.00** [b]
Category B		R197.00	R197.00	R225.00
Allied Health Practitioner	R184.00	R381.00	R381.00	R409.00
General Medical Practitioner	R189.00	R386.00	R386.00	R414.00
Specialist Medical Practitioner	R368.00	R565.00	R565.00	**R593.00** [b]
Category C		R456.00	R456.00	R521.00
General Medical Practitioner	R294.00	R750.00	R750.00	R815.00
Specialist Medical Practitioner	R900.00	R1 356.00	R1 356.00	**R1 421.00** [b]
Category D		R912.00	R912.00	R1 041.00
General Medical Practitioner	R585.00	R1 497.00	R1 497.00	R1 626.00
Specialist Medical Practitioner	R1 798.00	R2 710.00	R2 710.00	**R2 839.00** [b]
Category E		R2 324.00	R2 324.00	R2 657.00
General Medical Practitioner	R2 152.00	R4 476.00	R4 476.00	R4 809.00
Specialist Medical Practitioner	R4 488.00	R6 812.00	R6 812.00	**R7 145.00** [b]

Source: Free State Department of Health

[a]Applicable to Pelonomi Tertiary Hospital

[b]Prices combining professional- and facility fees applicable to this study.

Table 2: Descriptive Statistics.

Type of injury	Total patients (n = 1 380)		Mean age in years (31.39[b])		Mean days spent in hospital	Total patients who received imaging (n = 1 273)[c]
	Male	Female	Male	Female		
	Gender Ratio					
Blunt assaults (37.46%[a])	n = 517		32.48	34.11	12.07	485
	450	67				
	7:1					
Penetrating assaults (53.77%[a])	n = 742		30.40	31.26	7.45	679
	670	72				
	9:1					
Combination assaults (2.46%[a])	n = 34		29.06	26.50	9.18	31
	32	2				
	16:1					
Gunshot injuries (6,30%[a])	n = 87		31.93	34.73	10.71	78
	76	11				
	7:1					

Source: Authors' own work

[a]Percentage of total injuries

[b]Mean age for entire sample

[c]Totals used in cost analysis calculations

Table 3: Modality specific facility- and professional fees.

	X-ray (*n* = 3 834)	Ultrasound (*n* = 21)	CT (*n* = 1 566)	MRI (*n* = 38)	Fluoroscopy (*n* = 16)	Total examinations (*n* = 5 475)
Facility fees	R 319 770.00	R 5 317.00	R 2 197 422.00	R 100 966.00	R 8 464.00	R 2 631 939.00
Professional fees	R 523 584.00	R 8 792.00	R 3 759 858.00	R 170 544.00	R 14 128.00	R 4 476 906.00
Total	**R 843 354.00**	**R 14 109.00**	**R 5 957 280.00**	**R 271 510.00**	**R 22 592.00**	**R 7 108 845.00**

Source: Authors' own work

Table 4: Average cost of imaging per injury type.

	Patients who received imaging (*n* = 1 273)	Total imaging cost per injury type	Average imaging cost per injury type
Blunt assault	485	R3 259 685.00	R6 721.00
Penetrating assault	679	R3 164 805.00	R4 660.98
Combination assault	31	R228 742.00	R7 378.77
Gunshot injury	78	R455 613.00	R5 841.19

Source: Authors' own work

Table 5: Comparing Patient Day Equivalents (PDE) and Expenditure per Patient Day Equivalents (ExPDE) between the study sample and the Pelonomi Tertiary Hospital (1 July 2017 - 31 December 2017).

	Hospital PDEs*	Hospital ExPDE*	Total Hospital Expenditure per Month
July	19 396.50	R3 809.10	R73 883 208.15
August	19 722.70	R3 477.00	R68 575 827.90
September	18 566.70	R3 733.80	R69 324 344.46
October	20 159.50	R3 515.30	R70 866 690.35
November	18 518.50	R4 155.00	R76 944 367.50
December	15 457.70	R4 224.70	R65 304 145.19
Total	**111 821.6**		**R424 898 583.55**

$$Hospital\ ExPDE\ (1\ Jul - 31\ Dec\ 2017) = \frac{Total\ Hospital\ Expenditure\ for\ the\ Study\ Period}{Total\ PDEs\ for\ the\ Study\ Period} = \frac{R424\,898\,583{,}55}{111\,821{,}6}$$

R3 799.79
Pelonomi Hospital's ExPDE for the period 1 July 2017 - 31 December 2017

$$Imaging\ ExPDE\ (1\ Jul - 31\ Dec\ 2017) = \frac{Total\ Imaging\ cost\ for\ the\ Study\ Period}{Sample's\ PDEs\ for\ the\ Study\ Period} = \frac{R7\,108\,845{,}00}{9319}$$

Study Sample PDEs

Total admission Days:

9221

1/3rd of non-admission patients:

98

Total PDEs:

9319

R762.83
Study Sample's Imaging ExPDE for the period 1 July 2017 - 31 December 2017

*Financial Information supplied by the Pelonomi Tertiary Hospital's Information Unit

Source: Authors' own work

List of Appendices:

Appendix I

HEALTH SCIENCES RESEARCH AND ETHICS APPROVAL

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Health Sciences Research Ethics Committee

09-May-2018

Dear **Dr Tiaan Steyn**

Ethics Clearance: **Cost Analysis of Violence-Related Medical Imaging in a Free State Tertiary Trauma Unit**
Principal Investigator: **Dr Tiaan Steyn**
Department: **Clinical Imaging Sciences (Bloemfontein Campus)**

APPLICATION APPROVED

Please ensure that you read the whole document

With reference to your application for ethical clearance with the Faculty of Health Sciences, I am pleased to inform you on behalf of the Health Sciences Research Ethics Committee that you have been granted ethical clearance for your project.

Your ethical clearance number, to be used in all correspondence is:**UFS-HSD2018/0052/2905**

The ethical clearance number is valid for research conducted for one year from issuance. Should you require more time to complete this research, please apply for an extension.

We request that any changes that may take place during the course of your research project be submitted to the HSREC for approval to ensure we are kept up to date with your progress and any ethical implications that may arise. This includes any serious adverse events and/or termination of the study.

A progress report should be submitted within one year of approval, and annually for long term studies. A final report should be submitted at the completion of the study.

The HSREC functions in compliance with, but not limited to, the following documents and guidelines: The SA National Health Act. No. 61 of 2003; Ethics in Health Research: Principles, Structures and Processes (2015); SA GCP(2006); Declaration of Helsinki; The Belmont Report; The US Office of Human Research Protections 45 CFR 461 (for non-exempt research with human participants conducted or supported by the US Department of Health and Human Services- (HHS), 21 CFR 50, 21 CFR 56; CIOMS; ICH-GCP-E6 Sections 1-4; The International Conference on Harmonization and Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH Tripartite), Guidelines of the SA Medicines Control Council as well as Laws and Regulations with regard to the Control of Medicines, Constitution of the HSREC of the Faculty of Health Sciences.

For any questions or concerns, please feel free to contact HSREC Administration: 051-4017794/5 or email EthicsFHS@ufs.ac.za.

Thank you for submitting this proposal for ethical clearance and we wish you every success with your research.

Yours Sincerely

Dr. SM Le Grange
Chair : Health Sciences Research Ethics Committee

Appendix II

FREE STATE PROVINCIAL DEPARTMENT OF HEALTH ETHICS APPROVAL

health
Department of
Health
FREE STATE PROVINCE

10 April 2018

Dr. T Steyn
Dept. of Clinical Imaging Science
UFS

Dear Dr T Steyn

Subject: Cost Analysis of Violence-Related Medical Imaging in a Free State Tertiary Trauma Unit

- Please ensure that you read the whole document, Permission is hereby granted for the above – mentioned research on the following conditions:
- Serious Adverse events to be reported to the Free State department of health and/ or termination of the study
- Ascertain that your data collection exercise neither interferes with the day to day running of Pelonomi Hospital nor the performance of duties by the respondents or health care workers.
- Confidentiality of information will be ensured and please do not obtain information regarding the identity of the participants.
- **Research results and a complete report should be made available to the Free State Department of Health on completion of the study (a hard copy plus a soft copy).**
- Progress report must be presented not later than one year after approval of the project to the Ethics Committee of the University of Free State and to Free State Department of Health.
- Any amendments, extension or other modifications to the protocol or investigators must be submitted to the Ethics Committee of the University of Free State and to Free State Department of Health.
- **Conditions stated in your Ethical Approval letter should be adhered to and a final copy of the Ethics Clearance Certificate should be submitted to** sebeelats@fshealth.gov.za **before you commence with the study**
- No financial liability will be placed on the Free State Department of Health
- Please discuss your study with the institution manager/CEOs on commencement for logistical arrangements
- Department of Health to be fully indemnified from any harm that participants and staff experiences in the study
- Researchers will be required to enter in to a formal agreement with the Free State department of health regulating and formalizing the research relationship (document will follow)
- You are encouraged to present your study findings/results at the Free State Provincial health research day
- Future research will only be granted permission if correct procedures are followed see http://nhrd.hst.org.za

Trust you find the above in order.
Kind Regards

Dr D Motau
HEAD: HEALTH
Date: 20/04/18

Head : Health
PO Box 227, Bloemfotein, 9300
4th Floor, Executive Suite, Bophelo House, cnr Maitland and, Harvey Road, Bloemfotein
Tel: (051) 408 1646 Fax: (051) 408 1556 e-mail:khusemj@fshealth.gov.za@fshealth.gov.za/chikobvup@fshealth.gov.za

Appendix III

HEAD OF DEPARTMENT APPROVAL
CLINICAL IMAGING SCIENCES

REQUEST FOR APPROVAL TO PERFORM MEDICAL RESEARCH

Dr Tiaan P Steyn
Registrar: Clinical Imaging Sciences
UFS Student Number: 2006002220
HPCSA Registrar Post Number: O-31/01/25
PERSAL Number: 55213707

05 January 2018

Dr FA Gebremariam
Head of Department: Clinical Imaging Sciences
Universitas Academic Hospital
1 Logeman Street
Universitas
Bloemfontein, 9301

Dear Dr. Gebremariam

Herewith my formal request to perform medical research as per the requirement for the M.Med. post-graduate program at the Faculty of Health Sciences, University of the Free State.

My research aims to determine the cost of medical imaging incurred by Pelonomi Academic Hospital as a result of violence-related injuries that are treated at the Pelonomi Trauma Unit. The information will be valuable to determine the financial burden of violence in our society on the diagnostic imaging services at Pelonomi Academic Hospital. Patient information will be treated confidentially.

The commencement of the research is subject to the approval by the Health Sciences Research Ethics Committee of the University of the Free State, the CEO of Pelonomi Academic Hospital and the MEC of health of the Free State province.

Your approval will be greatly appreciated.

Yours sincerely,

Dr TP Steyn

PERMISSION GRANTED	✓
PERMISSION NOT GRANTED	

Signed: Dr FA Gebremariam
HOD: Clinical Imaging Sciences
Date: 17/01/2018

Appendix IV

HEAD OF DEPARTMENT APPROVAL
PELONOMI HOSPITAL TRAUMA UNIT

REQUEST FOR APPROVAL TO PERFORM MEDICAL RESEARCH

Dr Tiaan P Steyn
Registrar: Clinical Imaging Sciences
UFS Student Number: 2006002220
HPCSA Registrar Post Number: O-31/01/25
PERSAL Number: 55213707

05 January 2018

Dr CA Loubser
Head of Unit: Pelonomi Academic Hospital Trauma Unit
Pelonomi Academic Hospital
121 Dr Belcher Road
Heidedal
Bloemfontein, 9301

Dear Dr. Loubser

Herewith my formal request for permission to access the Pelonomi Academic Hospital Trauma Unit's patient registry. This information will be used for medical research as per the requirement for the M.Med. post-graduate program at the Faculty of Health Sciences, University of the Free State.

My research aims to determine the cost of medical imaging incurred by Pelonomi Academic Hospital as a result of violence-related injuries that are treated at the Pelonomi Trauma Unit. Patient information will be treated confidentially.

The commencement of the research is subject to the approval by the Health Sciences Research Ethics Committee of the University of the Free State, the CEO of Pelonomi Academic Hospital and the MEC of health of the Free State province.

Your approval will be greatly appreciated.

Yours sincerely,

Dr TP Steyn

PERMISSION GRANTED	✓
PERMISSION NOT GRANTED	

Signed: Dr CA Loubser
HOU: Pelonomi Hospital Trauma Unit

Date:

Appendix V

ELECTRONIC DATA CAPTURING FORM

PATIENT DEMOGRAPHICS				INCIDENT AND MODE OF INJURY			X-Rays (QUANTITY OF INVESTIGATIONS)					ULTRASOUND (QUANTITY OF INVESTIGATIONS)					COM
Q1_Hospital_Number	Q2_Admission_Date	Q3_Age (0 - 100)	Q4_Gender (0 = M; 1 = F)	Q5_Penetrating_Injury (0 = No; 1 = Yes)	Q6_Blunt_Injury (0 = No; 1 = Yes)	Q7_Gunshot (0 = No; 1 = Yes)	XR_CAT_A	XR_CAT_B	XR_CAT_C	XR_CAT_D	XR_CAT_E	US_CAT_A	US_CAT_B	US_CAT_C	US_CAT_D	US_CAT_E	CT_CAT_A

PUTED TOMOGRAPHY (CT) (QUANTITY OF INVESTIGATIONS)				MAGNETIC RESONANCE IMAGING (MRI) (QUANTITY OF INVESTIGATIONS)					FLUOROSCOPY (QUANTITY OF INVESTIGATIONS)					TOTAL INVESTIGATIONS				
CT_CAT_B	CT_CAT_C	CT_CAT_D	CT_CAT_E	MRI_CAT_A	MRI_CAT_B	MRI_CAT_C	MRI_CAT_D	MRI_CAT_E	RF_CAT_A	RF_CAT_B	RF_CAT_C	RF_CAT_D	RF_CAT_E	TOT_CAT_A	TOT_CAT_B	TOT_CAT_C	TOT_CAT_D	TOT_CAT_E

Appendix VI

TURNITIN PLAGIARISM REPORT

TurnItIn

by Tiaan Steyn

Submission date: 18-Oct-2018 07:20AM (UTC+0200)
Submission ID: 1022163916
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Word count: 3739
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Full Title:

Cost analysis of violence-related medical imaging in a Free State tertiary trauma unit.

Tweet:

How much does violence-related imaging cost?

Authors:

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Registrar

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Dr. Fekade Admassu Gebremariam (F.G.)

Head of Department

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Authors' Contributions:

F.G. and T.S. conceptualised and designed the study. F.G. and T.S. conducted the preliminary literature review and obtained ethical clearance from the relevant ethical committees. Data capturing and preliminary processing of data was performed by T.S. The University of the Free State's Department of Biostatistics assisted with the statistical analysis of the data. Cost calculations were performed by T.S. The article was drafted by T.S after which input and final approval was obtained from F.G.

Disclaimer:

The views and opinions expressed in this article are those of the authors and do not necessarily reflect those of their affiliated institutions.

Source(s) of support:

The authors did not rely on any financial support. Hospital-related financial information was obtained from the Pelonomi Tertiary Hospital's Information Unit.

Summary:

Words:	2 510
Pages:	10
Tables:	5
Figures:	0

Title:

Cost analysis of violence-related medical imaging in a Free State tertiary trauma unit

Abstract:

Background:

Violence is a leading public health problem worldwide, beyond the pain and suffering, violence has a significant economic impact on a country's health, policing, and judicial services. Due to the lack of current and comprehensive data in South Africa, local violence-related economic impact studies are largely estimations. Violence-related imaging expenditure, as a component of a public hospital's expenditure, is yet to be determined.

Objectives:

To measure the violence-related patient burden on Pelonomi Tertiary Hospital's (PTH) trauma and radiology services, determine the imaging-component cost of violence-related injuries and calculate the financial burden violence has on the hospital's expenditures.

Method:

From the PTH's Trauma Unit patient registry, 1 380 patients with violence-related injuries were consecutively sampled for the six months ending 31 December 2017. Imaging investigations were documented and categorised according to the South African National Department of Health's (SANDOH) 2017 Uniform Patient Fee Schedule (UPFS). Descriptive analysis and cost calculations were performed using the 2017 UPFS tariff schedule and hospital-specific health efficiency indicators i.e. Patient Day Equivalent (PDE) and Expenditure per Patient Day Equivalent (ExPDE).

Results:

Violence-related injuries accounted for 50.64% of all trauma department visits and received a total of 5 475 imaging investigations. Violence-related imaging investigations represented 14.81% of all investigations performed by the radiology department in the study period. Overall violence-related admission costs amounted to R35 410 241.85 (8.33% of the hospital's total expenditure) of which 20.08% (R7 108 845.00) was attributed to imaging investigations.

Conclusion:

Violence-related admissions had a high patient and financial burden on PTH. The pinnacle of health care cost saving is violence prevention; however, the cost-conscious radiologist could assist with cost saving if responsible and ethical imaging practices are followed.

Introduction:

In 2008, violence was earmarked as the leading cause of death (31.5%) among 31 177 unnatural deaths recorded in the National Injury Mortality Surveillance System report of South Africa, however, it was already in 1996 at the Geneva World Health Assembly that violence was declared a leading worldwide public health problem.[1]

Locally, the South African Police Service precincts in and around Bloemfontein reported a total of 8 101 crimes in the categories of attempted murder, assault with the intent to inflict grievous bodily harm, common assault and robbery with aggravating circumstances. This was for the period 1 April 2017 to 31 March 2018.[2]

Beyond the pain and suffering caused, violence has a significant economic impact on society, both directly and indirectly. Some of the direct costs include: those borne by the victim and perpetrator as a result of the violence, loss of productivity at work, and government expenditure relating to the health care, policing- and judicial services.[3–7]

Due to a lack of comprehensive data in South Africa, local cost-analysis studies can only estimate the economic impact of violence.[8]

The provincial Departments of Health showed the second highest expenditure of all government departments, spending close to R150 billion in the 2015/2016 fiscal year. This translated to an average cost of R3 332 per person using public health care services in South Africa.[9–11] This is an extremely high burden on both the national and provincial governments' budgets when taking into consideration that, in 2014, health care contributed close to nine percent of South Africa's Gross Domestic Product.[12]

Health information (e.g. cost analysis studies) is crucial in the planning, implementation, evaluation and management of health care resources, seeing that 82% of the South African population rely on the public health care system.[10,13–16]

There are limited studies in the South African literature that specifically focuses on the cost of medical imaging in violence-related injuries. Imaging investigations are expensive and the South African Competition Commission's Health Market Inquiry found that medical aid claims relating to imaging investigations increased by an average of 10.98% per year between 2011 and 2014.[17]

The objective of this study was two-fold. Firstly, to determine the violence-related patient burden on trauma and radiology services at PTH, and secondly, to determine the cost of violence-related medical imaging and contextualising this cost in terms of PTH's total expenditure.

Research methods and design:

Study design:

This study was a descriptive cost analysis which aimed to measure the cost of violence-related medical imaging in the setting of a tertiary level public hospital. Due to the complexity of cost analysis studies, the most practical method for estimating this cost was to use the SANDOH's 2017 Uniform Patient Fee Schedule (UPFS). The UPFS is a fee schedule used to bill patients using public health care facilities and is applicable to externally funded patients using public hospitals in all provinces throughout South Africa.

Therefore, the study could more accurately be defined as a descriptive cost analysis using the theoretical maximum cost that can be charged by the hospital for medical imaging. Although the data might not reflect the exact cost of performing the imaging investigations, it does provide an estimation thereof.

According to the UPFS, all imaging investigations are categorised from category A to category E according to the complexity of the investigation. Furthermore, each category consists of two fixed prices: A facility fee (depending on the service level of the hospital) and a professional fee (depending on the training level of the health care practitioner who interprets the imaging investigation). The 2017 UPFS imaging fees are presented in Table 1.[18]

Research setting and sampling method:

The PTH's Trauma Unit served as the study population. This unit provides emergency medical care to the whole of central South Africa (Free State and parts of the Northern- and Eastern Cape) and keeps a detailed electronic patient registry including the diagnosis/mechanisms of injury. Due to resource constraints and a high turnover of patients in the trauma unit, violence-related injuries for a 6-month period (1 July 2017 to 31 December 2017), were selectively used to ensure a manageable sample size.

Consecutive sampling was used to retrospectively select patients from the Trauma Unit's patient registry. Inclusion criteria consisted of patients of any age who were attended to in the above-mentioned period and who sustained violence-related injuries in the subgroups of 'penetrating assaults', 'blunt assaults', 'combination of blunt- and penetrating assaults' or 'gunshot injuries'.

Accidental- and self-inflicted injuries were excluded, as well patients who were dead on arrival. Patients who did not receive any imaging were excluded from cost calculations.

Double registry entries and registry entries with missing data, which could not be recovered from the Hospital Information System, were also excluded.

Data collection:

The Trauma Unit's electronic database (Microsoft Excel Format) was filtered according to the inclusion and exclusion criteria. Each entry in the filtered database was manually cross referenced with the Hospital Information System (to eliminate database errors) and to obtain each patient's discharge date. Hereafter, all directly identifiable patient information (name, surname, identity number) were removed from the database to ensure patient confidentiality. Patients were only identified with their hospital numbers.

Hospital numbers and admission dates were cross referenced with the Picture Archiving and Communication System (PACS). Each individual examination which was performed during the patient's first admission were documented under the relevant modality and UPFS category A to E (using the UPFS procedure book). The procedure book contains more than 800 individual radiological investigations and procedures, and for this reason, investigations were not further subcategorised. Examinations were categorised from A – E and priced according to UPFS service level 3 facility fees and UPFS specialist professional fees.

The final database contained the number of imaging investigations performed for each patient categorised under the different imaging modalities and UPFS pricing categories.

Data analysis:

Descriptive statistics were calculated for continuous data and frequencies and percentages were calculated for categorical data.

Arithmetic- and cost calculations, incorporating the 2017 UPFS tariffs as well as health care efficiency indicators and relevant hospital expenses for the study period (obtained from the hospital's Information Unit), were used to calculate relevant imaging costs and proportionality between imaging costs and hospital expenditure.

Limitations:

Imaging investigations performed outside the radiology department e.g. fluoroscopy in theatre and eFAST ultrasounds in the trauma unit, are not uploaded to the PACS, and were subsequently not included in the study. This could have led to an underestimation in the total cost of imaging.

Contrast agents administered during the imaging investigations were not included in the cost analysis due to varying cost between the different brands as well as poor documentation of the exact amount and type of contrast that was administered.

Patients seen at PTH's casualty department (separately functioning department from the trauma unit) were not included in the study – this was due to the lack of an electronic patient registry.

Ethical Considerations:

Ethical clearances were obtained from the University of the Free State's Health Sciences Research Ethics Committee (UFS-HSD2018/0052) as well as the Free State Provincial Health Research Committee (FS_201803_010).

All directly identifiable patient information (names, surnames, dates of birth) were removed to ensure patient confidentiality.

Results:

A total of 4 966 patients were treated at PTH's trauma unit in 2017 of which 2 725 patients were treated during the period 1 July 2017 to 31 December 2017. Within this period, 1 380 patients matched the inclusion and exclusion criteria. Violence-related injuries constituted 50.64% of all trauma department visits during the study period.

Descriptive statistics are summarised in Table 2.

The sample of 1 380 patients included 1 228 males (mean age of 31.22 years) and 152 females (mean age of 32.71 years). The study sample's injuries consisted of 53.77% penetrating injuries, 37.46% blunt injuries, 2.46% combination injuries and 6.3% gunshot injuries. A combined 5 475 individual imaging investigations were performed on 1 273 patients in the study sample. A total of 107 patients did not receive any imaging and were excluded from further cost calculations.

General X-rays represented the bulk of the imaging investigations totalling 3 834 investigations and amounted to R843 354.00. Computed Tomography (CT) scans totalled 1 566 investigations, however, contributed to the highest cost of R5 957 280.00. A detailed breakdown of imaging cost per imaging modality are presented in Table 3. A total of 5 475 imaging investigations amounted to R7 108 845.00 of which R2 631 939.00 represented level 3 hospital facility fees and R4 476 906.00 the specialist professional fees.

The average cost of imaging investigations for the different injury types are presented in Table 4.

From the patient sample, 978 patients (70.87%) were admitted to hospital with a combined total of 9 221 admission days. Patients who were not admitted to hospital totalled 295.

Discussion:

Although the Uniform Patient Fee Schedule (UPFS) applies to externally funded patients being treated in a public hospital, it should be noted that all state patients are billed according to the UPFS tariffs. The UPFS tariffs applicable to imaging investigations are used by public hospitals to incorporate the cost of imaging into performance indicators as well as used for financial analyses and budgeting.

After the invoicing is done, a patient may qualify for a rebate. The percentage rebate is dependent on the income level of the patient and other factors. Rebates may be up to 100% in H0 classified patients (pensioners and formally unemployed patients) and 0% in H3 patients (therefore full paying patients). Where rebates apply, the rebates are covered by the hospital. Aspects such as actual patient invoicing, debt collection and the reconciliation thereof are beyond the scope of the study. Instead, the study used the theoretical maximum that could be charged to patients for medical imaging received in a tertiary government hospital i.e. no rebates were considered. Therefore, if all patients in the study sample were regarded as H0 classified patients, the total invoice for imaging services would have had to be covered by the hospital.

The billing total of imaging performed in the study sample was R7 108 845.00. This includes both the professional fees and the facility fees as set out in the UPFS. This billing total is an underestimation of the true amount due to the previously stated limitations.

In the study sample, general X-rays were the most frequently performed investigation (n = 3 834) and contributed 11.9% to the total imaging bill, whereas CT scans (n = 1 566) contributed 83.8% (R5 957 280.00) to the total bill. The modality with the third highest cost was Magnetic Resonance Imaging (MRI) (n = 38) totalling R271 510.00, followed by Ultrasound (n = 21) and Fluoroscopy (n = 16) which totalled R14 109.00 and R22 592.00 respectively. In perspective, for every R1.00 the hospital billed for imaging in violence-related injuries, 84c was for CT scans, 12c for X-rays and 4c for MRI. The cost of ultrasound- and fluoroscopic investigations were negligible, because records pertaining to ultrasounds performed by trauma personnel and screening procedures performed in theatre, were not available for analysis.

Medical imaging, as a component of in-hospital services and costs, can be put into perspective by determining the patient burden on radiology services as well as what share it holds in the hospital's total expenditure. The radiology department performed a total of 36 956 imaging investigations in the study period. Violence-related imaging investigations, referred from the trauma unit, constituted 14.81% of all these investigations, however, this is an underestimation due to the study limitations and considering that none of the casualty department's violence-related imaging referrals were included in the study.

To put the imaging costs into perspective, comparison to the hospital's overall expenditure is needed. This can be done by comparing the data to the hospital's Expenditure per Patient Day Equivalent (ExPDE). ExPDE is widely used as a proxy for a hospital's cost-effectiveness and is calculated by dividing the hospital's total expenditure by the hospital's Patient Day Equivalent (PDE). A single PDE is a unit which can represent one or more patient depending on the hospital resources the patient or patients consume in a 24-hour period. This is calculated by using all inpatient days, half of out-patient visits and a third of emergency department visits. The rationale behind the formula is that out-patient visits and emergency department visits are estimated to consume one half and one third, respectively, of the resources spent on a single 24-hour patient admission. Therefore, ExPDE represents the average cost per patient per 24-hour services rendered by the hospital.[19]

Before comparing the data to the hospital's ExPDE, an "Imaging Expenditure per Patient Day Equivalent" was calculated in accordance with the ExPDE formula. This provided an average imaging cost per PDE for the study sample.

The study sample included 978 patient hospital admissions with a total of 9 221 admission days. This represented 9 221 PDEs. One third of the remaining non-admission patients represented 98 PDEs which led to a total of 9 319 PDEs in the study sample. Dividing the total imaging cost with the sample's PDE amounted to an Imaging ExPDE of R762.83. Thus, the average cost of imaging per violence-related admission day was R762.83. Calculations are summarised in Table 5.

Calculated from PTH's financials for the study period, irrespective of the admitting department, the average cost per patient per 24-hours (ExPDE) was R3 799.79. When the study sample was compared to the hospital's ExPDE, violence-related imaging was found to constitute 20.08% of the hospital's average cost per patient per 24-hour admission. Consequently, this proved that a considerable portion of money was spent on medical imaging in violence-related hospital admissions.

Using PTH's ExPDE and the study sample's PDEs, the hospital spent a total of R35 410 241.85 on violence-related trauma admissions for the last six months of 2017. This translated to 8.33% of the hospital's total expenditure of R424 898 583.55 for this period. Seeing that violence is unlikely to disappear in the foreseeable future, all role players in the management chain of violence-related hospital admissions should be cost-conscious and avoid unnecessary expenditure.

Violence and its associated injuries are closely related, therefore, similar studies at set intervals may not only prove useful as cost analysis studies, but also prove as useful indicators of the incidence of violence, the financial burden on health care services as well as the effectiveness of existing violence prevention strategies and campaigns.

Conclusion:

Violence often lead to injury and the need for health care. During the last 6 months of 2017, 92.2% (n = 1 273) of violence-related trauma department visits to PTH received imaging. The radiology department, therefore, plays an important role in the management chain of violence-related injuries. Violence-related admissions from the trauma unit cost PTH R35 410 241.85 in the last six months of 2017. An underestimated 20.08% of this expenditure was attributable to imaging investigations. Although we, as radiologists, can't prevent violence at ground level, the services we provide constitute a significant portion of violence-related health care cost. In South Africa, with regular budget shortages, a recently announced technical recession, and the anticipated implementation of National Health Insurance, the need for cost-saving strategies are becoming ever more important.

Acknowledgements:

The authors would like to thank Cornel van Rooyen from the Department of Biostatistics, University of the Free State, for his assistance in the statistical analysis of the data as well as Geranda Opperman for her assistance in ensuring the data integrity of the initial database.

Competing interests:

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Author contributions:

F.G. and T.S. conceptualised and designed the study. F.G. and T.S. conducted the preliminary literature review and obtained ethical clearance from the relevant ethical committees. Data capturing and preliminary processing of data was performed by T.S. The University of the Free State's Department of Biostatistics assisted with the statistical analysis of the data. Cost calculations were performed by T.S. The article was drafted by T.S after which input and final approval was obtained from F.G.

Funding:

No funding was needed for the study.

Disclaimer:

The views and opinions expressed in this article are those of the authors and do not necessarily reflect those of their affiliated institutions.

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GRADEMARK REPORT

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GENERAL COMMENTS

Instructor

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Appendix VII

SOUTH AFRICAN JOURNAL OF RADIOLOGY
PUBLISHING AUTHOR GUIDELINES

AOSIS Publishing house style for authors

Manuscripts must adhere to the following guide before submission.

Table of content

Physical Address: 15 Oxford Street, Durbanville, 7550.
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Language usage

General elements

- **Quotations:** Use single quotation marks for quotations. For quotations within quotations, use double quotation marks. Quotations of more than 30 words are to be indented. Do not use quotation marks for indented quotations unless it is direct speech (e.g. interviewee responses).
- **En dashes and hyphens:** Use an en dash (i.e. extended hyphen that can be found in the Insert box under Symbols in Microsoft Word) in ranges of numbers and dates. Use hyphens only for words that are hyphenated.
- **Dates:** Format dates as '02 October 2006', except at the beginning of sentences where numerals and dates should either be spelt out or the sentence should be rearranged.
- **Percentage:** The per cent symbol (%) is used in conjunction with all numbers (e.g. 12%). Numbers that have been written out will appear with 'percent' (e.g. five percent). 'Percentage' is used in a general sense.
- **Numbers:** Numbers from one to nine must be written out. Numbers from 10 onwards, must be used as numerals, except at the beginning of a sentence.
- **Spacing and punctuation:** There should be one space (and not two) between sentences; one space before unit terms (e.g. 5 kg, 5 cm, 5 mmol, 5 days, 5 °C, etc.), but no space before the percentage symbol (%). Thousands and millions are marked with a space and *not* a comma (e.g. 1000, 1 000 000). Ranges are expressed with an extended hyphen (i.e. en dash), not with a short hyphen (e.g. 1990–2000).
- **Units:** The use of units should conform to the SI convention and be abbreviated accordingly. Metric units and their international symbols are used throughout, as in the decimal point (not the decimal comma), and the 24-hour clock.
- **Foreign language:** Foreign language words should be italicised, unless these words are part of normal usage. Consult the Oxford English Dictionary if in doubt.
- **Acronyms:** If a phrase with an established acronym or abbreviation is used and appears more than five times in your manuscript, please include the acronym or abbreviation in brackets after first mention of the phrase, and then use the acronym or abbreviation only. Please note that you should not define acronyms or abbreviations in any of your headings. If either has been used in your abstract, you need to define them again on their first usage in the main text.

Sensitive and political terms

- **Race and ethnicity**: Try to avoid terms such as 'blacks' and 'whites'; use instead 'black *people'*, 'white *people'*, etc. 'Caucasian', 'Mongoloid', 'Negroid', etc. are generally to be avoided except in human population studies. 'Mixed race' is preferable to 'half-caste' or 'coloured'.
- **Disabilities:** Avoid using 'the disabled', 'the handicapped', and instead use 'people with disabilities not 'the disabled' or 'people with learning difficulties', not 'mentally handicapped'.
- **Disease**
    - Avoid health-determined categorisation.
        - Use 'people with diabetes'; not 'diabetics'.
        - Use 'people with cancer'; not 'cancer sufferers'.

        - Use 'sexually transmitted infection (STI)' and not 'sexually transmitted disease (STD)'.
    - Avoid phrasing that dehumanises a patient. Many authors use case (instance of a disease) when they mean patient (i.e. the person or individual who is ill with the (disease).
- AIDS
    - Ensure that 'AIDS' is used for the disease and 'HIV' for the virus, e.g. do not use 'AIDS carrier', 'AIDS positive', 'AIDS virus' or 'catching AIDS or HIV/AIDS' (avoid using the solidus here).
    - 'AIDS sufferer/victim' is inappropriate; use 'people with AIDS'.
    - Refer to 'people who practise high-risk activities' and not '*high-risk groups'.*
    - The expression 'full-blown AIDS' is unnecessary if the correct distinction has been made between HIV and AIDS.
- Male versus Female
    - 'Male' and 'female' are *adjectives*, so be careful to use them as such (i.e. a *male* patient and a *female* frog, but a 35-year-old *man*, a French *woman* and a group of 25 *men* and 35 *women*).
- **Sexuality:** Avoid the terms '*homosexual activities'* (if achievable within the manuscript's context, specify which activity is being referred to, especially when dealing with medical research.) Avoid using '*homosexuals'* (specify homosexual men or homosexual women).
- **Gender:** Use gender neutral nouns. Avoid the use of 'man' if not specifically referring to men; for example:
    - for 'man' use 'humans'
    - for 'man-kind' use 'the human race'
    - for 'man-power' use 'workforce'
    - for 'man-made fibre' use 'synthetic fibre'
- **'He/she', 'him/her' and 'his/hers':** For 'he/she', 'him/her' and 'his/hers' rather use 'he or she', 'her or him', 'his or hers' (without a solidus) or change to plural 'they'. Use inclusive pronouns: use 'he or she', or rephrase the sentence (rephrasing to the plural form often works):

✗ … *Any observer* of changes in publishing technology will perceive that *he* has need of…

✓ … *Observers* of… will perceive that *they* have…

Beware of referring to people with stereotypical pronouns (e.g. 'the doctor treated *his* patient'; 'the secretary tidied *her* desk').

- Geography
    - The terms *Third World*, *poor countries* and *underdeveloped countries* should be avoided.
    - *Developing* or *non-developed country/society* is better, but it is best to specify countries or regions instead.
    - *Western society* and *Western World* should only be used in relation to geography; otherwise, use *developed world/society* or, even better, specify the countries themselves or the region.

Tables, figures and photographs

Tables should in an Excel (.xls) format. Ensure that all personal identifying information is removed from the supplementary files as indicated in the provided instructions. All captions should be provided together on a separate page. Tables and figures should use numerical numbers.

- Organise your visual presentation: Once you have read through the analyses and decided how best to present each table or figure, think about how you will arrange them within the manuscript. The analyses should tell a story' that leads the reader through the steps needed to logically answer the question(s) that you as author are posing in the Introduction. The order in which you present the results can be as important in convincing the readers as what you actually are saying in the text.
- **How to refer to tables and figures in the text:** Every figure and table included in the paper *must* be referred to in the body of the text. Use sentences that draw the reader's attention to the relationship or trend you wish to highlight, referring to the appropriate figure or table only in parenthesis e.g.:
    - Germination rates were significantly higher after 24 h in running water than in controls (Figure 4).
    - DNA sequence homologies for the purple gene from the four congeners (Table 1) show high similarity, differing by at most 4 base pairs. (Avoid sentences that give no information other than directing the reader to the figure or table, e.g. Table 1 shows the summary results for male and female heights at Bates College.)
- **Abbreviation of the word 'Figure':** When referring to a figure in the text, the word 'figure' is never abbreviated as 'Fig.'; the same rule applies to the usage of 'table'. Both words are spelled out completely in descriptive legends.
- **How to number tables and figures:** Figures and tables are numbered independently, in the sequence in which you refer to them in the text, starting with Figure 1 and Table 1. If, in revision, you change the presentation sequence of the figures and tables, you must renumber them to reflect the new sequence.
- **The acid test for tables and figures:** Any table or figure you present must be clear, well-labelled, and described by its legend to be understood by your intended audience without reading the results section. That is, it must be able to stand alone and be interpretable. Overly complicated figures or tables may be difficult to understand in or out of context, so strive for simplicity whenever possible.
- **Descriptive legends or captions:** To pass the acid test above, a clear and complete legend (sometimes called a caption) is essential. Like the title of the manuscript itself, each legend should convey as much information as possible about what the table or figure intends to tell the reader:
    - the results that are being shown in the graph(s), including the summary statistics plotted
    - the organism studied in the experiment (if applicable)
    - a context for the results: the treatment applied or the relationship displayed, etc.
    - location (*only* if a field experiment)
    - specific explanatory information needed to interpret the results shown (in tables, this is frequently done as footnotes)
    - culture parameters or conditions if applicable (temperature, media, etc.)

- sample sizes and statistical test summaries, as they apply

Do not simply restate the axis labels with a 'versus' written in between.

Example: Figure 1: Height frequency (%) of White Pines (Pinusstrobus) in the Thorncrag Bird Sanctuary, Lewiston, Maine, before and after the Ice Storm of 1998. Before, *n* = 137, after, *n* = 133. Four trees fell during the storm and were excluded from the post-storm survey.

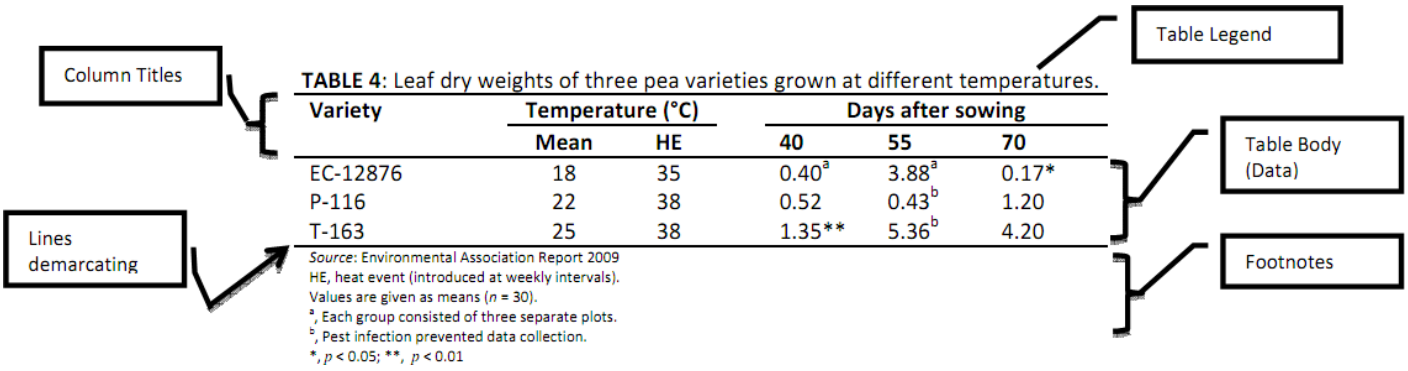

TABLE 4: Leaf dry weights of three pea varieties grown at different temperatures.

Variety	Temperature (°C)		Days after sowing		
	Mean	HE	40	55	70
EC-12876	18	35	0.40[a]	3.88[a]	0.17*
P-116	22	38	0.52	0.43[b]	1.20
T-163	25	38	1.35**	5.36[b]	4.20

Source: Environmental Association Report 2009
HE, heat event (introduced at weekly intervals).
Values are given as means (*n* = 30).
[a], Each group consisted of three separate plots.
[b], Pest infection prevented data collection.
*, $p < 0.05$; **, $p < 0.01$

Note: Questions frequently arise about how much methodology to include in the legend, and how much results reporting should be done. For laboratory reports, specific results should be reported in the results text with a reference to the applicable table or figure. Other than culture conditions, methods are similarly confined to the Methods section.

Footnotes to tables, figures and photographs

Do not introduce footnotes in the body of the manuscript. Footnotes should be used as follows:

- Copyright and permissions to reproduce should be clearly stated.
- Notes about the table as a whole can be left unlinked (i.e. no linking letters or numbers or symbols) or linked to, for example, a relevant column heading.
- Notes about specific parts of the table should be linked using superscript lower case letters (preferred), superscript numbers or symbols.
- If lower case letters are used, it could be confused with the table data; use symbols or numbers instead.
- Do not make use of superscript numbers in parentheses (brackets).
- If an abbreviation is mentioned for the first time in a table (e.g. 'CE' in Table 1), it must be defined in a footnote to that table, (e.g. HE, Heat event (introduced at weekly intervals).
- Asterisk footnotes are reserved for probability values in tables and usually signify the following values: *, $p \leq 0.05$; **, $p \leq 0.01$; ***, $p \leq 0.001$. The asterisk is often used in mathematics and should therefore be avoided as a footnote symbol.
- Footnote links should be placed after punctuation. The preferred order of footnote symbols in tables (which should be superscripted) is †, ‡, §, ¶ (these are doubled if more footnotes are needed, e.g. ††).
- When superscript numbers or letters are used in text, beware of potential confusion with other superscripts (e.g. 2 for 'squared').
- Footnotes should be in the following order:

- source notes
- other general notes
- notes on specific parts of the table (following the order in the table itself)
- notes on level of probability

Guidance on submitting creatives electronically

Please supply images as the size intended for final publication. Resizing of images is time consuming and can result in loss of quality.

Supply your manuscript creatives in one of the following three preferred formats:

- **TIFF:** This is an image made up of pixels and is the most universal and most widely supported format across Windows and Mac platforms. Most graphics packages can save a file as a TIFF. The higher the resolution (i.e. the number of pixels) the sharper the final image.
  - Colour or greyscale photographic images: 300dpi
  - Line art or combination images: 600/900dpi
  - We would recommend using this format for photographic images.
- **EPS**: An EPS is essentially an envelope for holding text and images. Line art can be produced as an EPS (in Illustrator, for example). There are virtually no limits to scaling line art saved as an EPS. It can also contain TIFF images. However, please ensure that all fonts are embedded (that is, saved as outlines) and that line weights are not defined as hairline.
- **PDF**: This format is, again, like an EPS in that it is an envelope for holding different kinds of images and line art. Great care should be taken to ensure that fonts are embedded and that original images are at the correct size and resolution before being saved as a PDF. It is possible to save or export as TIFF or EPS from most graphics applications, just as it is possible to save direct to a PDF from most graphics packages by using a postscript printer driver. PDF creation packages (e.g. Acrobat Distiller) are also now widely available.

Other file formats

- **JPEG**: A JPEG compressed TIFF is acceptable as long as the degree of compression is moderate. It is better to use a JPEG for online images as a good quality image is achievable even with a high degree of compression.
- **GIF**: A format suitable for images that contain few colours. Again, this should only be used for images intended for the web.
- We cannot guarantee the quality of images supplied in other formats.

Colour:

- *Greyscale, CMYK, RGB.*
- **Greyscale** art should be saved in greyscale mode.
- **C**yan**M**agenta**Y**ellow**B**lack are the base colours used during the printing process.
- Any colour that is to appear in print must be in CMYK mode.
- **R**ed**G**reen**B**lue are the colours used by monitors and default scanner settings. Any colour that is to appear online must be in RGB mode.

Guidelines for Math

- Set display equations in MathType. Each display equation should be in its own MathType object. Each MathType object should contain the entire equation, including final punctuation. The equation number should be set as Microsoft Word regular text, outside the MathType object, separated by either a tab or a space.
- Set in-text (inline) math in Microsoft Word regular text. Exception: If in-text (inline) math has elements that should be stacked or have rules, circumflexes, arrows, or other accents spanning over more than one character, set in MathType as 'Inline Equation.'
- If any characters cannot be found in Word's Symbol palette ('(normal text),' 'Times New Roman,' or 'Symbol'), please set in MathType.
- No display equations are allowed in figure captions, table titles, or table footnotes. If a display equation occurs in a text footnote, it is best to recast it as inline math. There are a few journals with lengthy footnotes with style exceptions to this rule.
- No numbered equations are allowed in table footnotes.
- Display and/or numbered equations ARE allowed in table body, but must be 'inline' when converted to MathML equations.

Fonts: Unicode fonts

Please use standard (UNIcode) fonts such as Palatino, Times New Roman, Helvetica and Symbol. Fonts that have not been embedded will usually be replaced by Courier, resulting in character loss or realignment.

Understanding Unicode

The explanation at Unicode.org is a good place to begin.

'Unicode provides a unique number for every character, no matter what the platform, no matter what the program, no matter what the language.' (Unicode.org, 2011)

Put more simply, no matter what font is used, your computer and other computers will always know exactly what symbol is called for and display the text correctly.

Note: AOSIS Publishing publishes in four different formats, namely, PDF, HTML, XML and ePUB. If your manuscript is not unicode compliant, then it will not be possible to produce all four formats. We will send the back to you to make the fonts Unicode compliant to enable us to produce all four formats.

How to check whether your font-type is unicode compliant

1. Open your manuscript in your text editor.
2. Highlight all the text within your manuscript and change the font to Arial or Times New Roman.
3. Scrutinise your entire manuscript.
    - **Document reads perfectly?** If the words are readable and identifiable, then the font that you are using is unicode compliant.
    - **Document has changed certain or all characters?** Font used is not unicode compliant and needs to be changed prior to submission to this journal.

Which fonts are Unicode compliant?

- To use Unicode, you will need to install (or find already installed) Unicode fonts on your computer. This is neither difficult nor costly.
- For basic information and links to numerous Unicode fonts, see http://www.alanwood.net/unicode/fonts.html
    - Arial Unicode MS
    - Courier New
    - DejaVu Serif
    - Gentium
    - Garamond
    - Minion Pro
    - Myriad Pro
    - Tahoma
    - Times New Roman
    - Verdana

Unicode in Windows

Installing fonts on a Windows computer is fairly simple.

1. Download the font.
2. If it is a compressed file (such as .zip), expand it.
3. Open the fonts folder by clicking on Start, then Settings, then Control Panel, then Fonts.
4. Drag the font file(s) into this folder. It should automatically install.

Using the insert symbol function

- Use the Insert Symbol function (found in the Insert menu). This function allows you to choose characters from a grid displayed in its own window. Double-clicking the desired character inserts it at the cursor in the document.
- Use the symbol insert window to assign keystrokes to the characters you use most often. For example, you might assign the keystroke alt+a to the lower case a with macron, and alt+shif+A to capital A with macron.

Keyboard for Windows

The preferred method for typing in Unicode. Essentially this means telling Windows that you want a different keyboard layout to be available for use. At this step things might vary from computer to computer.

- Click on Start, then Settings, then Control Panel.
- Double click Regional and Language Options. The window that opens should have three tabs: Regional Options, Languages, and Advanced.
- Click on the Keyboards and Languages tab.
- Options include installing additional languages or changing the keyboard. Read the guidelines provided by Windows carefully.
- Select 'Change keyboards' in the same window after installing additional language.
- To make it your default keyboard you must choose it in the drop down list under Default Input Language at the top of this window. Click Add.
- Proceed to select the 'Language Bar' tab at the top and ensure that the box 'Show additional Language bar icons in the taskbar' is ticked.

- Now there should be a little keyboard icon in the task bar at the bottom of your screen (if there wasn't already). (It will be next to the blue square with EN in it, which signifies that the current input language is English. If you use no other languages, this icon might not be there.) When you click on the small keyboard icon, a list of keyboard choices pops up. If you made Alt-Latin the default, it should be in bold type. (However, it may not appear until the next time you restart your computer. Until then it might be a blank line in the list.)

Typing with the alternative keyboard is simple. For most letters you will do things as you always have. When you need a special character or a character with a diacritic or accent, you will use key combinations with the Alt key to the right of the space bar (the one on the left side does not work for this in Windows, unfortunately). For example, to type the letter 'a' with a macron you hold down the Alt key and press the letter a, release them both, then type the letter a. For letters with a dot below them, hold down Alt, press the period key, release both, and then type the letter which needs the dot.

Unicode in Macintosh

To enter Unicode text on a Macintosh, you have several options.
Firstly, you may use the **Character Pallette**, which is found in the Input Menu (the flag menu in the upper right, near the clock).

- If the Character Pallette option is not shown, enable it by doing the following:
  - Go to the Apple menu, select System Preferences.
  - In the Preferences window, choose International.
  - Select Input Menu.
  - Check Character Pallette. You can also check Keyboard Viewer, Unicode Hex Input, and US Extended at this time.
  - Check Alt-Latin. If it is not there, see below for information on installing it.
  - Make sure the "Show Input Menu in menu bar" option is checked.
- To use the Character Pallette to enter Unicode characters in a document, just keep it open in the background. When you need a character, you can enter it by double clicking on it in Character Pallette.
- A useful feature of Character Pallette is the ability to designate frequently-used characters as favourites, saving you the trouble of finding the different letters each time you need them.
- For more information on Character Pallette, see Alan Wood's site: http://www.alanwood.net/unicode/utilities_fonts_macosx.html

Secondly, you may use the excellent and extremely simple **Alt-Latin keyboard** or **LatinTL keyboard**, both of which were created specifically for this purpose by Kino.

- To install either keyboard (or both of them), you must first download AltLatin.zip and/or LatinTL_X.dmg.sit from Alt-Latin page).
- If your browser does not automatically expand the .zip or .sit file, tell it to save the file to your desktop (so it will be easy to find), then manually expand it. Usually this can be done simply by double-clicking the file, which will start the appropriate decompression program. LatinTL expands to a disk image, but for the purpose of installation you can treat it just like a folder.
- Follow the instructions in the 'readme' file to install the keyboard(s).

- Make it visible in the Input Menu by following the instructions given above for the Character Pallette.
- Because Alt-Latin and LatinTL work like any other keyboard, you will not have to change keyboards unless you need to type in a different alphabet, such as Arabic.
- Entering letters with diacritics using either keyboard is very simple:
    1. Make sure you are using a Unicode font. It may work with other fonts, but you should use Unicode (OS X comes with Lucida Grande and there are others available).
    2. To enter a vowel with a macron, simply hold down either **option** key and hit the letter 'a' simultaneously. Release them, then type the letter that needs the macron (using the shift key if you need a capital).
    3. For letters with dots below, press option and period, release, then type the letter.
    4. Hamza is shift+option+P, and 'ayn is option+p. (This may not work in Microsoft Word with Alt-Latin – reason unknown. If it does not work, use the LatinTL keyboard instead, or use the Character Pallette for these two characters. These keystrokes do work in TextEdit and other software with Alt-Latin.)
- The PDF file included with Alt-Latin shows maps of the keyboard, in case you need something not mentioned here, or you may use our maps found on http://www.lib.uchicago.edu/e/collections/mideast/encyclopedia/unicode.html.
- The layout of LatinTL is very similar, with only a few differences, and it also includes maps. (See the Alt-Latin page for a description of the differences.)
- **Click** here **for diagrams of the Alt-Latin keyboard** (usable for LatinTL as well, with a few differences) and for downloads.
- The diagrams are for the Windows version, but the layout is almost identical to the Mac version. The main difference is that where the Windows version uses only the Alt key to the right of the space bar, the Mac version uses either of the two Option keys. This makes the Mac version a little more comfortable to use, since you can use either hand. (There is no Windows version of LatinTL.)
- There are downloadable PDF files of the diagrams available on the same page, in case you would like to print them for easier reference while typing.
- Kino's site (linked above) also has numerous other Macintosh keyboard and font resources, such as some keyboards based on non-US layouts (notably a UK variant of Alt-Latin).

Thirdly, you may want to use Knut S. Vikør's **Jaghbub keyboard layouts** (and, perhaps, his Unicode fonts).
His Arabic Macintosh pages have long been one of the web's most useful sources for Mac users who need to type Arabic or transliteration, and he has updated both the pages and the downloadable resources he created.

- The page on transliteration, 'Writing Arabic with Latin letters', explains the issues and provides a downloadable file containing the JaghbUni font package and the American Diacs. keyboard layout.
- The Jaghbub font package page gives more information about the three fonts included, as well as German, French, Italian, Danish, Swedish, Norwegian, US and UK keyboard layouts for typing diacritics in Unicode fonts.
- There are also separate keyboard layouts for typing IPA characters in Unicode fonts for the same national standards (that is, the non-option keys

follow the regular national keyboard standard, but the IPA characters are all placed on option keys under no particular standard).

For any keyboard layout, you can always select **Keyboard Viewer** from the Input Menu to see what different keystrokes will do.

These instructions were taken from:
http://www.lib.uchicago.edu/e/collections/mideast/encyclopedia/unicode.html

Appendix VIII

PUBLISHED ARTICLE

SOUTH AFRICAN JOURNAL OF RADIOLOGY

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Cost analysis of violence-related medical imaging in a Free State tertiary trauma unit

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Background: Violence is a leading public health problem worldwide. Beyond the pain and suffering, violence has a significant economic impact on a country's health, policing and judicial services. Because of the lack of current and comprehensive data in South Africa, local violence-related economic impact studies are largely estimations. Violence-related imaging expenditure, as a component of a public hospital's expenditure, is yet to be determined.

Objectives: The goals of this study were to measure the violence-related patient burden on Pelonomi Tertiary Hospital's (PTH) trauma and radiology services, determine the imaging-component cost of violence-related injuries and calculate the financial burden violence has on the hospital's expenditures.

Method: From the PTH's trauma unit patient registry, 1380 patients with violence-related injuries were consecutively sampled for 6 months ending 31 December 2017. Imaging investigations were documented and categorised according to the South African National Department of Health's 2017 Uniform Patient Fee Schedule (UPFS). Descriptive analysis and cost calculations were performed using the 2017 UPFS tariff schedule and hospital-specific health efficiency indicators – patient-day equivalent and expenditure per patient-day equivalent.

Results: Violence-related injuries accounted for 50.64% of all trauma department visits and received a total of 5475 imaging investigations. Violence-related imaging investigations represented 14.81% of all investigations performed by the radiology department in the study period. Overall violence-related admission costs amounted to R35 410 241.85 (8.33% of the hospital's total expenditure), of which 20.08% (R7 108 845.00) was attributed to imaging investigations.

Conclusion: Violence-related admissions had a high patient and financial burden on PTH. The pinnacle of healthcare cost saving is violence prevention; however, the cost-conscious radiologist could assist with cost saving if responsible and ethical imaging practices are followed.

Introduction

In 2008, violence was earmarked as the leading cause of death (31.5%) among 31 177 unnatural deaths recorded in the National Injury Mortality Surveillance System report of South Africa. However, violence had already been declared a leading worldwide public health problem in 1996 at the Geneva World Health Assembly.[1]

Locally, the South African Police Service precincts in and around Bloemfontein reported a total of 8101 crimes in the categories of attempted murder, assault with the intent to inflict grievous bodily harm, common assault and robbery with aggravating circumstances. This was for the period 01 April 2017 to 31 March 2018.[2]

Beyond the pain and suffering caused, violence has a significant economic impact on society, both directly and indirectly. Some of the direct costs include those borne by the victim and perpetrator as a result of the violence, loss of productivity at work, government expenditure relating to healthcare, policing and judicial services.[3,4,5,6,7]

Because of a lack of comprehensive data in South Africa, local cost analysis studies can only estimate the economic impact of violence.[8] The provincial Departments of Health showed the second highest expenditure of all government departments, spending close to R150 billion in the 2015–2016 fiscal year. This translated to an average cost of R3332 per person using public healthcare services in South Africa.[9,10,11] This is an extremely high burden on both the national

and provincial governments' budgets when taking into consideration that, in 2014, healthcare contributed close to 9% of South Africa's gross domestic product.[12]

Health information (e.g. cost analysis studies) is crucial in the planning, implementation, evaluation and management of healthcare resources, seeing that 82% of the South African population rely on the public healthcare system.[10,13,14,15,16]

There are limited studies in the South African literature that specifically focus on the cost of medical imaging in violence-related injuries. Imaging investigations are expensive and the South African Competition Commission's Health Market Inquiry found that medical aid claims relating to imaging investigations increased by an average of 10.98% per year between 2011 and 2014.[17]

The objective of this study was twofold. Firstly, we aimed to determine the violence-related patient burden on trauma and radiology services at Pelonomi Tertiary Hospital (PTH), and secondly, to determine the cost of violence-related medical imaging and to contextualise this cost in terms of PTH's total expenditure.

Research methods and design

Study design

This study was a descriptive cost analysis that aimed to measure the cost of violence-related medical imaging in the setting of a tertiary-level public hospital. Because of the complexity of cost analysis studies, the most practical method for estimating this cost was to use the South African National Department of Health's 2017 Uniform Patient Fee Schedule (UPFS). The UPFS is a fee schedule used to bill patients using public healthcare facilities, and it is applicable to externally funded patients using public hospitals in all provinces throughout South Africa.

Therefore, the study could more accurately be defined as a descriptive cost analysis using the theoretical maximum cost that can be charged by the hospital for medical imaging. Although the data might not reflect the exact cost of performing the imaging investigations, it does provide an estimation thereof.

According to the UPFS, all imaging investigations are categorised from category A to category E according to the complexity of the investigation. Furthermore, each category consists of two fixed prices: a facility fee (depending on the service level of the hospital) and a professional fee (depending on the training level of the healthcare practitioner who interprets the imaging investigation). The 2017 UPFS imaging fees are presented in Table 1.[18]

TABLE 1: 2017 Uniform patient fee schedule imaging tariffs.

Category of investigation	Professional fee	Facility fee		
		Level 1	Level 2	Level 3†
Category A	-	**R72**	**R72**	**R80**
Allied health practitioner	R69	R141	R141	R149
General medical practitioner	R70	R142	R142	R150
Specialist medical practitioner	R131	R203	R203	R211‡
Category B	-	**R197**	**R197**	**R225**
Allied health practitioner	R184	R381	R381	R409
General medical practitioner	R189	R386	R386	R414
Specialist medical practitioner	R368	R565	R565	R593‡
Category C	-	**R456**	**R456**	**R521**
General medical practitioner	R294	R750	R750	R815
Specialist medical practitioner	R900	R1356	R1356	R1421‡
Category D	-	**R912**	**R912**	**R1041**
General medical practitioner	R585	R1497	R1497	R1626
Specialist medical practitioner	R1798	R2710	R2710	R2839‡
Category E	-	**R2324**	**R2324**	**R2657**
General medical practitioner	R2152	R4476	R4476	R4809
Specialist medical practitioner	R4488	R6812	R6812	R7145‡

†, Applicable to Pelonomi Tertiary Hospital; ‡, Prices combining professional and facility fees applicable to this study.

Research setting and sampling method

The PTH's trauma unit served as the study population. This unit provides emergency medical care to the whole of central South Africa (Free State and parts of the Northern and Eastern Cape) and keeps a detailed electronic patient registry including the diagnosis and mechanisms of injury. Because of resource constraints and a high turnover of patients in the trauma unit, violence-related injuries for a 6-month period (01 July 2017 to 31 December 2017) were selectively used to ensure a manageable sample size.

Consecutive sampling was used to retrospectively select patients from the trauma unit's patient registry. Inclusion criteria consisted of patients of any age who were attended to in the study period and who sustained violence-related injuries in the subgroups of 'penetrating assaults', 'blunt assaults', 'combination of blunt and penetrating assaults' or 'gunshot injuries'.

Accidental and self-inflicted injuries were excluded, as well as patients who were dead on arrival. Patients who did not receive any imaging were excluded from cost calculations. Double registry entries and registry entries with missing data, which could not be recovered from the Hospital Information System, were also excluded.

Data collection

The trauma unit's electronic database (Microsoft Excel format) was filtered according to the inclusion and exclusion criteria. Each entry in the filtered database was manually cross referenced with the Hospital Information System (to eliminate database errors) and to obtain each patient's discharge date. Hereafter, all directly identifiable patient information (name, surname, identity number) were removed from the database to ensure patient confidentiality. Patients were only identified with their hospital numbers.

Hospital numbers and admission dates were cross referenced with the Picture Archiving and Communication System (PACS). Each individual examination performed during the patient's first admission was documented under the relevant

modality and UPFS category A to E (using the UPFS procedure book). The procedure book contains more than 800 individual radiological investigations and procedures, and for this reason, investigations were not further subcategorised. Examinations were categorised from A to E and priced according to UPFS service level-3 facility fees and UPFS specialist professional fees.

The final database contained the number of imaging investigations performed for each patient categorised under the different imaging modalities and UPFS pricing categories.

Data analysis

Descriptive statistics were calculated for continuous data and frequencies and percentages were calculated for categorical data.

Arithmetic and cost calculations, incorporating the 2017 UPFS tariffs, as well as healthcare efficiency indicators and relevant hospital expenses for the study period (obtained from the hospital's information unit), were used to calculate relevant imaging costs and proportionality between imaging costs and hospital expenditure.

Limitations

Imaging investigations performed outside the radiology department such as fluoroscopy in theatre and extended Focussed Assessment with Sonography in Trauma, done in the trauma unit, are not uploaded to the PACS and were subsequently not included in the study. This could have led to an underestimation in the total cost of imaging.

Contrast agents, administered during the imaging investigations were not included in the cost analysis because of varying cost between the different brands, as well as poor documentation of the exact amount and type of contrast that was administered.

Patients seen at PTH's casualty department (a separately functioning department from the trauma unit) were not included in the study – this was because of the lack of an electronic patient registry.

Ethical consideration

Ethical clearances were obtained from the University of the Free State's Health Sciences Research Ethics Committee (UFS-HSD2018/0052), as well as the Free State Provincial Health Research Committee (FS_201803_010). All directly identifiable patient information (names, surnames, dates of birth, etc.) were removed to ensure patient confidentiality.

Results

A total of 4966 patients were treated at PTH's trauma unit in 2017, of which 2725 patients were treated during the period 01 July 2017 to 31 December 2017. Within this period, 1380 patients matched the inclusion and exclusion criteria. Violence-related injuries constituted 50.64% of all trauma department visits during the study period. Descriptive statistics are summarised in Table 2.

The sample of 1380 patients included 1228 males (mean age of 31.22 years) and 152 females (mean age of 32.71 years). The study sample's injuries consisted of 53.77% penetrating injuries, 37.46% blunt injuries, 2.46% combination injuries and 6.3% gunshot injuries. A combined 5475 individual imaging investigations were performed on 1273 patients in the study sample. A total of 107 patients did not receive any imaging and were excluded from further cost calculations.

General X-rays represented the bulk of the imaging investigations, totalling 3834 investigations, and amounted to R843 354.00. Computed tomography (CT) scans totalled 1566 investigations; however, they contributed to the highest cost of R5 957 280.00. A detailed breakdown of imaging cost per imaging modality is presented in Table 3. A total of 5475 imaging investigations amounted to R7 108 845.00, of which R2 631 939.00 represented level-3 hospital facility fees and R4 476 906.00 the specialist professional fees.

The average costs of imaging investigations for the different injury types are presented in Table 4.

From the patient sample, 978 patients (70.87%) were admitted to hospital with a combined total of 9221 admission days. Patients who were not admitted to hospital totalled 295.

TABLE 2: Descriptive statistics.

Type of injury	*n*	%	Gender ratio (male:female)	Total patients (*n* = 1380)		Mean age in years (31.39)‡		Mean days spent in hospital	Total patients who received imaging (*n* = 1273)§
				Male	Female	Male	Female		
Blunt assaults	517	37.46†	7:1	450	67	32.48	34.11	12.07	485
Penetrating assaults	742	53.77†	9:1	670	72	30.40	31.26	7.45	679
Combination assaults	34	2.46†	16:1	32	2	29.06	26.50	9.18	31
Gunshot injuries	87	6.30†	7:1	76	11	31.93	34.73	10.71	78

†, Percentage of total injuries; ‡, Mean age for entire sample; §, Totals used in cost analysis calculations.

TABLE 3: Modality-specific facility and professional fees.

Fees	X-ray (*n* = 3834)	Ultrasound (*n* = 21)	CT (*n* = 1566)	MRI (*n* = 38)	Fluoroscopy (*n* = 16)	Total examinations (*n* = 5475)
Facility fees	R319 770.00	R5317.00	R2 197 422.00	R100 966.00	R8464.00	R2 631 939.00
Professional fees	R523 584.00	R8792.00	R3 759 858.00	R170 544.00	R14 128.00	R4 476 906.00
Total	**R843 354.00**	**R14 109.00**	**R5 957 280.00**	**R271 510.00**	**R22 592.00**	**R7 108 845.00**

CT, computed tomography; MRI, magnetic resonance imaging.

TABLE 4: Average costs of imaging per injury type.

Injury type	Patients who received imaging (*n* = 1273)	Total imaging cost per injury type	Average imaging cost per injury type
Blunt assault	485	R3 259 685.00	R6721.00
Penetrating assault	679	R3 164 805.00	R4660.98
Combination assault	31	R228 742.00	R7378.77
Gunshot injury	78	R455 613.00	R5841.19

Discussion

Although the UPFS applies to externally funded patients being treated in a public hospital, it should be noted that all state patients are billed according to the UPFS tariffs. The UPFS tariffs applicable to imaging investigations are used by public hospitals to incorporate the cost of imaging into performance indicators, as well as being used for financial analyses and budgeting.

After the invoicing is done, a patient may qualify for a rebate. The percentage rebate is dependent on the income level of the patient and other factors. Rebates may be up to 100% in H0 classified patients (pensioners and formally unemployed patients) and 0% in H3 patients (therefore full paying patients). Where rebates apply, the rebates are covered by the hospital. Aspects such as actual patient invoicing, debt collection and the reconciliation thereof, are beyond the scope of the study. Instead, the study used the theoretical maximum that could be charged to patients for medical imaging received in a tertiary government hospital – in other words, no rebates were considered. Therefore, if all patients in the study sample were regarded as H0 classified patients, the total invoice for imaging services would have had to be covered by the hospital.

The billing total of imaging performed in the study sample was R7 108 845.00. This includes both the professional fees and the facility fees, as set out in the UPFS. This billing total is an underestimation of the true amount because of the previously stated limitations.

In the study sample, general X-rays were the most frequently performed investigation (*n* = 3834) and contributed 11.9% to the total imaging bill, whereas CT scans (*n* = 1566) contributed 83.8% (R5 957 280.00) to the total bill. The modality with the third highest cost was magnetic resonance imaging (MRI) (*n* = 38) totalling R271 510.00, followed by ultrasound (*n* = 21) and fluoroscopy (*n* = 16), which totalled R14 109.00 and R22 592.00, respectively. In perspective, for every R1.00 the hospital billed for imaging in violence-related injuries, R0.84 was for CT scans, R0.12 for X-rays and R0.04 for MRI. The costs of ultrasound and fluoroscopic investigations were negligible, because records pertaining to ultrasounds performed by trauma personnel and screening procedures performed in theatre were not available for analysis.

Medical imaging, as a component of in-hospital services and costs, can be put into perspective by determining the patient burden on radiology services, as well as what share it holds in the hospital's total expenditure. The radiology department performed a total of 36 956 imaging investigations in the study period. Violence-related imaging investigations, referred from the trauma unit, constituted 14.81% of all these investigations; however, this is an underestimation because of the study limitations and considering that none of the casualty department's violence-related imaging referrals were included in the study.

To put the imaging costs into perspective, comparison to the hospital's overall expenditure is needed. This can be done by comparing the data to the hospital's expenditure per patient-day equivalent (ExPDE). Expenditure per patient-day equivalent is widely used as a proxy for a hospital's cost-effectiveness and is calculated by dividing the hospital's total expenditure, for a specific period, by the hospital's patient-day equivalent (PDE) for the same period. A single PDE is a unit that can represent one or more patients depending on the hospital resources the patient or patients consume in a 24-hour period. This is calculated by using all inpatient days, half of out-patient visits and a third of emergency department visits. The rationale behind the formula is that out-patient visits and emergency department visits are estimated to consume one-half and one-third, respectively, of the resources spent on a single 24-hour patient admission. Therefore, ExPDE represents the average cost per patient per 24-hour services rendered by the hospital.[19] Before comparing the data to the hospital's ExPDE, an 'imaging expenditure per patient-day equivalent' was calculated in accordance with the ExPDE formula. This provided an average imaging cost per PDE for the study sample.

The study sample included 978 patient hospital admissions with a total of 9221 admission days. This represented 9221 PDEs. One-third of the remaining non-admission patients represented 98 PDEs, which led to a total of 9319 PDEs in the study sample. Dividing the total imaging costs with the sample's PDE, amounted to an imaging ExPDE of R762.83. Thus, the average cost of imaging per violence-related admission day was R762.83. Calculations are summarised in Figure 1.

Calculated from PTH's financials for the study period, irrespective of the admitting department, the average cost per patient per 24-hours (ExPDE) was R3799.79. When the study sample was compared to the hospital's ExPDE, violence-related imaging was found to constitute 20.08% of the hospital's average cost per patient per 24-hour admission. Consequently, this proved that a considerable portion of money was spent on medical imaging in violence-related hospital admissions.

Using PTH's ExPDE and the study sample's PDEs, the hospital spent a total of R35 410 241.85 on violence-related trauma admissions for the last 6 months of 2017. This translated to 8.33% of the hospital's total expenditure of R424 898 583.55 for this period. Seeing that violence is unlikely to disappear in the foreseeable future, all role players in the management chain of violence-related hospital admissions should be cost-conscious and avoid unnecessary expenditure.

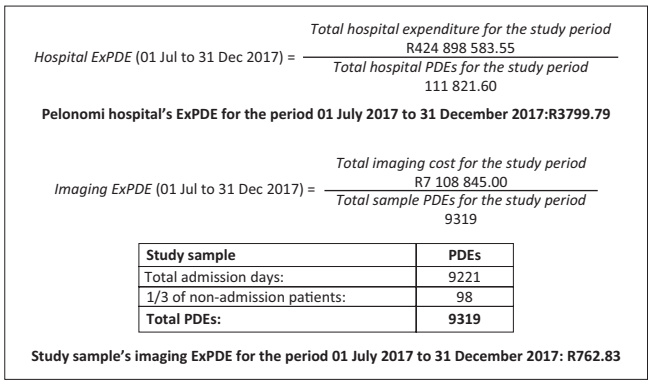

FIGURE 1: Hospital expenditure per patient day equivalent and imaging expenditure per patient day equivalent. PDE, patient-day equivalent; ExPDE, expenditure per patient-day equivalent.

Violence and its associated injuries are closely related; therefore, similar studies at set intervals may not only prove useful as cost analysis studies but also prove as useful indicators of the incidence of violence, the financial burden on healthcare services, as well as the effectiveness of existing violence prevention strategies and campaigns.

Conclusion

Violence often leads to injury and the need for healthcare. During the last 6 months of 2017, 92.2% (n = 1273) of violence-related trauma department visits to PTH received imaging. The radiology department, therefore, plays an important role in the management chain of violence-related injuries. Violence-related admissions from the trauma unit cost PTH R35 410 241.85 in the last 6 months of 2017. An underestimated 20.08% of this expenditure was attributable to imaging investigations. Although we, as radiologists, can't prevent violence at ground level, the services we provide constitute a significant portion of violence-related healthcare cost. In South Africa, with regular budget shortages, a recently announced technical recession and the anticipated implementation of National Health Insurance, the need for cost-saving strategies is becoming ever more important.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contribution

F.A.G. and T.P.S. conceptualised and designed the study, conducted the preliminary literature review and obtained ethical clearance from the relevant ethical committees. Data capturing and preliminary processing of data was performed by T.P.S. The University of the Free State's Department of Biostatistics assisted with the statistical analysis of the data. Cost calculations were performed by T.P.S. The article was drafted by T.P.S. after which input and final approval was obtained from F.A.G.

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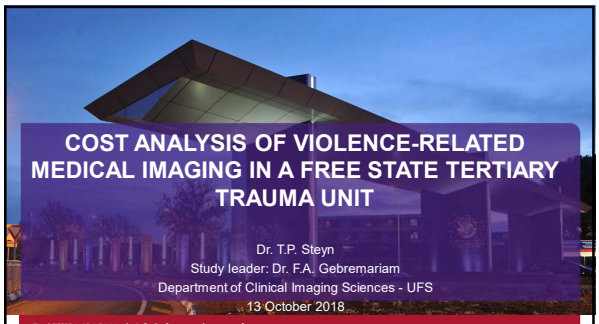
Appendix IX

PRESENTATION PRESENTED AT:

UFS FACULTY FORUM

&

RSSA INTERNATIONAL NEURO-IMAGING CONGRESS (AWARDED 1ST PRIZE)



COST ANALYSIS OF VIOLENCE-RELATED MEDICAL IMAGING IN A FREE STATE TERTIARY TRAUMA UNIT

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UFS·UV HEALTH SCIENCES GESONDHEIDSWETENSKAPPE

OVERVIEW

- INTRODUCTION
- OBJECTIVES
- METHODOLOGY
- RESULTS
- CONCLUSION

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INTRODUCTION

- **Violence:**
  - Caused **31.5%** of all unnatural deaths in RSA 2008[1]
  - SAPS Bloemfontein area 1 Apr 2017 – 31 Mar 2018[2,3]:
  - **8 101 reported crimes** for attempted murder, assault with intent to cause grievous bodily harm, common assault and robbery with aggravating circumstances.
  - Significant economic impact[4-8]:
    - Loss of work productivity
    - Government expenditure - Health, Judicial, Policing

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INTRODUCTION

- **Public Healthcare:**
  - **82%** of South Africans rely on public health care services[9]
  - In 2014 health care contributed to **8.8%** of the RSA GDP[10]
  - Provincial Depts Of Health ('16/'17 fiscal year)[11]:
    - **2nd largest spender** of all Provincial Departments
    - **≈R150 billion!!!**

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OBJECTIVES

Determine violence-related **PATIENT BURDEN** on:
Trauma Unit
Radiology Department

Determine **FINANCIAL BURDEN** of violence-related imaging on:
Hospital Expenditure

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METHODOLOGY

- **How did we do it?:**
  - Retrospectively & consecutively sampled
  - Violence-related injuries
  - Pelonomi Tertiary Hospital's trauma unit
  - Last 6 months of 2017
  - All age groups
  - 4 injury categories in patient registry that were sampled:
    - **Penetrating Assaults**
    - **Blunt Assaults**
    - **Penetrating/Blunt**
    - **Gunshot Injuries**

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METHODOLOGY

- **Exclusion criteria:**
  - Accidental- or self-inflicted injuries
  - Patients who were dead on arrival
  - Missing data
  - Patients who did not receive imaging during the admission were included in demographic analysis but excluded from cost calculations.

UFS UV

METHODOLOGY

Table 1: 2017 Uniform Patient Fee Schedule imaging tariffs.

Category of Investigation	Professional Fee	Facility fee		
		Level 1	Level 2	Level 3[a]
Category A		R72,00	R72,00	R80,00
Allied Health Practioner	R69,00	R141,00	R141,00	R149,00
General Medical Practioner	R70,00	R142,00	R142,00	R150,00
Specialist Medical Practitioner	R131,00	R203,00	R203,00	**R211,00** [b]
Category B		R197,00	R197,00	R225,00
Allied Health Practioner	R184,00	R381,00	R381,00	R409,00
General Medical Practioner	R189,00	R386,00	R386,00	R414,00
Specialist Medical Practitioner	R368,00	R565,00	R565,00	**R593,00** [b]
Category C		R456,00	R456,00	R521,00
General Medical Practioner	R294,00	R750,00	R750,00	R815,00
Specialist Medical Practitioner	R900,00	R1 356,00	R1 356,00	**R1 421,00** [b]
Category D		R912,00	R912,00	R1 041,00
General Medical Practioner	R585,00	R1 497,00	R1 497,00	R1 626,00
Specialist Medical Practitioner	R1 798,00	R2 710,00	R2 710,00	**R2 839,00** [b]
Category E		R2 324,00	R2 324,00	R2 657,00
General Medical Practioner	R2 152,00	R4 476,00	R4 476,00	R4 809,00
Specialist Medical Practitioner	R4 488,00	R6 812,00	R6 812,00	**R7 145,00** [b]

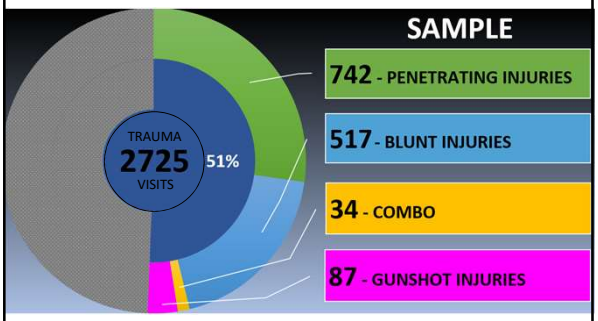
Source: Free State Department of Health
[a]Applicable to Pelonomi Tertiary Hospital
[b]Prices highlighted indicate combined professional- and facility fees applicable to this study.

UPFS 2017

- Government Price list
- For externally funded pts
  - 2 Fee Components
    - Professional Fee
    - Facility Fee
- Also used to bill state patients before discounts are applied
- Used for cost calculations and budgeting Govt Hospitals

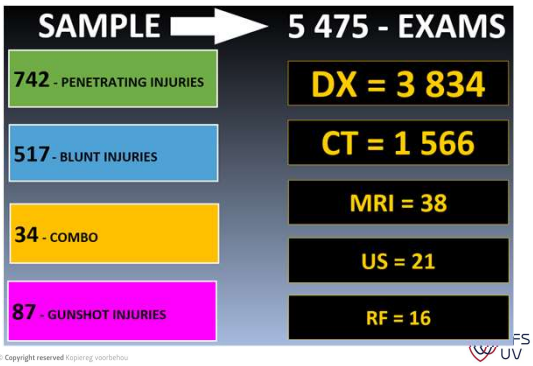
UFS UV

RESULTS



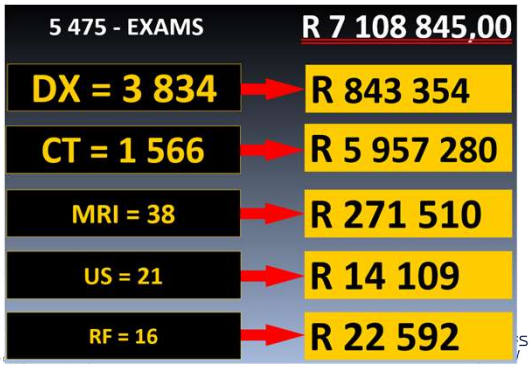
UFS UV

RESULTS

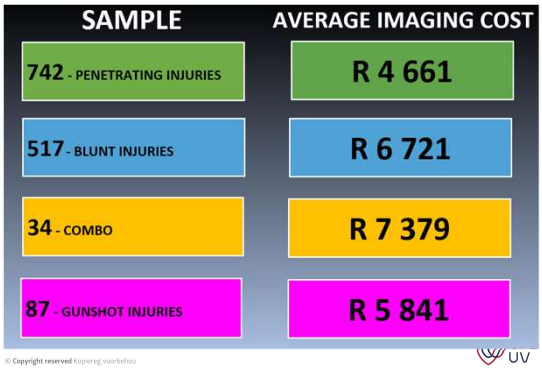


UFS UV

RESULTS



RESULTS



UV

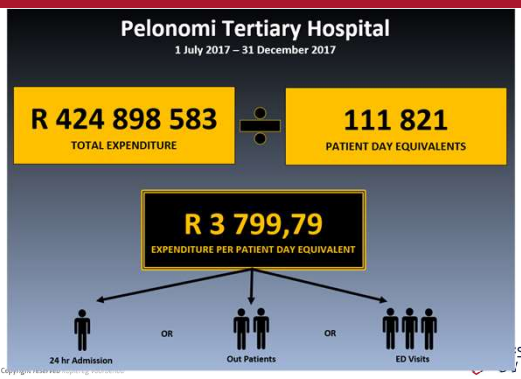
RESULTS

- **Patient Day Equivalent (PDE):**
  - Used widely as health care efficiency indicator
  - The equivalent of patients treated in a 24h period in hospital

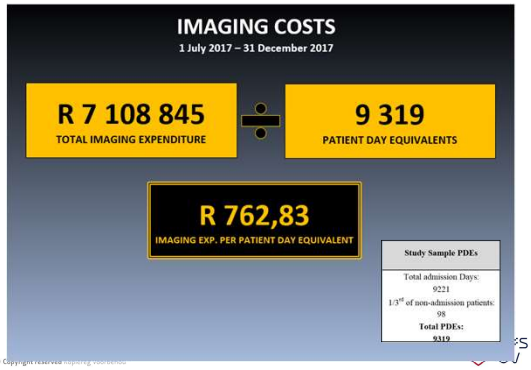
    All in-patients + $^1/_2$ out-patients + $^1/_3$ ED patients
  - Rationale:
    - 1x OPD patient consumes ≈ $^1/_2$ resources compared to an in-patient
    - 1x ED patient consumes ≈ $^1/_3$ resources compared to an in-patient
- **Expenditure per Patient Day Equivalent (ExPDE):**
  - Hospital expenditure per PDE

    TOTAL HOSP EXPENDITURE ÷ Patient Day Equivalent

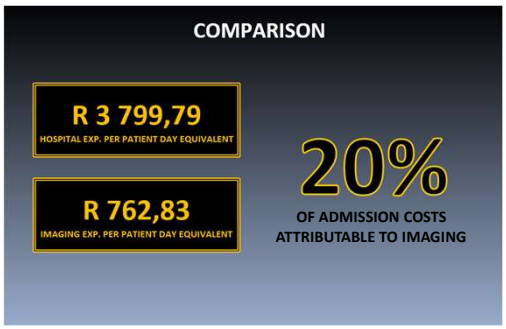
RESULTS



RESULTS



RESULTS



CONCLUSION

- Imaging plays a **MAJOR** role in the management chain of violence-related hospital admissions:

  –92% of violence-related injuries received imaging.
  - Violence-related admission costs using PTH's ExPDE:

    »R35 410 241,85

  –20% of the above costs relate to imaging

CONCLUSION

- **Why is all of this information important?**
  - Findings can supplement larger **economic impact studies** of violence in South Africa
  - Similar studies at different institutions can assist with **budgeting and resource allocations** as well comparison between different demographic areas
  - Repeating the study at set intervals may be an indirect indicator of the **incidence of violence** and be used to evaluate the **effectiveness** of violence-prevention strategies and campaigns

CONCLUSION

Applicability to Radiologists:

- Although we as Radiologists can't prevent violence, our services represent a

  5th of violence-related health care expenditure

- **It is our responsibility to:**
  - Acquaint ourselves with the cost of our services in public hospitals
  - Prevent unnecessary investigations
  - To ensure evidence-based imaging practices are followed

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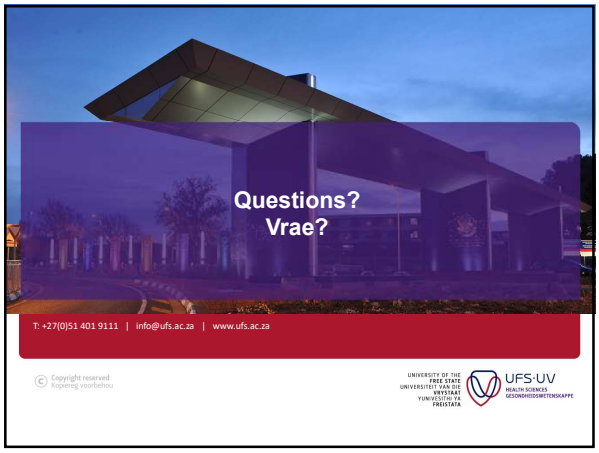

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