Emergency Clinician Output in a District Hospital Emergency Centre: a cross-sectional analysis

by

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Declaration

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List of Abbreviations

EC	Emergency Centre
HECTIS	Hospital and Emergency Centre Tracking Information System
IQR	Interquartile range
LMICs	Low- to middle-income countries
MPH	Mitchells Plain Hospital's
PPH	Patients consulted per hour
RVU/h	Relative value units per hour

Part A: Manuscript in Article Format

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Emergency clinician output in a district hospital emergency centre: a cross-sectional analysis

Abstract

Introduction

Appropriate and efficient staffing is a cornerstone of emergency centre performance. There is however a paucity of literature describing clinician output in low- and middle-income countries with current staffing models based on anecdotal evidence. This study aimed to assess clinician output at a district level emergency centre, and how it varied depending on shift, clinician, and workload factors.

Methods

We conducted a retrospective cross-sectional study using an existing electronic patient registry, to determine the patients consulted per hour (PPH) during each clinician shift and how this is affected by various clinician, shift, and workload factors. Data was collected over three non-contiguous randomly selected four-week cycles from Mitchells Plain Hospital's electronic patient registry. Associations between PPH and various factors were assessed using the ANOVA and post-hoc adjustments where appropriate. The correlation between PPH and workload metrics was calculated with the Pearson's Rank correlation test. Statistical significance was defined as $p<0.05$.

Results

A total of 1 289 clinician shifts were analysed with an overall PPH of 0.7. A significant association between PPH and shift type (p 0.021), clinician category ($p<0.001$) and cumulative shifts ($p<0.001$) were shown. There was a decline in clinician output during a shift and output was significantly decreased by the number of boarders in the emergency centre but increased with higher numbers of patients waiting at the start of the shift.

Conclusion

This study describes a relatively low clinician output as compared to evidence from high-income countries and has highlighted several associations with various shift, clinician, and workload factors. The results from this study will form the basis of quality improvement interventions to improve patient throughput and will inform staff scheduling and surge planning strategies.

Keywords

Emergency Medicine

Productivity

Low- to middle-income country

Crowding

Patient flow

African Relevance

- Appropriate and efficient staffing is a cornerstone of emergency centre performance.
- There is a paucity of literature describing clinician output in low- and middle-income countries with current staffing models based on anecdotal evidence.
- Clinician output was shown to be much lower than the expected output proposed by the American College of Emergency Physicians.
- Clinician output is affected by several factors including community, hospital, emergency centre and clinician factors.
- The results from this study will form the basis of quality improvement interventions to improve patient throughput and will inform staff scheduling and surge planning strategies.

STROBE Statement

	Item No	Recommendation	Page Number
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	9
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	9
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	13
Objectives	3	State specific objectives, including any prespecified hypotheses	14&15
Methods			
Study design	4	Present key elements of study design early in the paper	14
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	14
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up. *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls. *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	14&15
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	15
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	15
Bias	9	Describe any efforts to address potential sources of bias	15
Study size	10	Explain how the study size was arrived at	14&15
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	15
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	15
		(*b*) Describe any methods used to examine subgroups and interactions	15
		(*c*) Explain how missing data were addressed	15
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed. *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	15
		(*e*) Describe any sensitivity analyses	NA

Results			**Page Number**
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	16
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders	16&17
		(b) Indicate number of participants with missing data for each variable of interest	16
		(c) *Cohort study*—Summarise follow-up time (e.g., average, and total amount)	NA
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	NA
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	NA
		Cross-sectional study—Report numbers of outcome events or summary measures	18-20
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	16-22
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	22-24
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	22-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	23&24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25

Emergency clinician output in a district hospital emergency centre: a cross-sectional analysis

Introduction

Emergency Centre (EC) crowding has been described as both a patient safety issue and a worldwide public health problem.[1] The American College of Emergency Physicians defines crowding as when the identified need for emergency services exceeds available resources for patient care in the EC, hospital or both.[2] EC crowding has been associated with several adverse outcomes including increased morbidity and mortality, increased length of stay, increased costs, and decreased staff and patient satisfaction.[2,3] Low- to middle-income countries (LMICs) are not exempt: a study conducted in Khayelitsha Hospital, a district level hospital in the Western Cape of South Africa, found bed occupancy in the EC to be between 128 and 132%, depending on the time of day.[4] EC crowding in LMICs is further compounded by resource limitation, increased burden of disease and staffing shortages - 80% of LMICs have fewer than 10 medical doctors per 10 000 population with South Africa having 9.1/10 000 medical doctors per population compared with 25.95/10 000 in the United States of America.[5,6]

Appropriate and efficient staffing is a cornerstone of EC performance. Strategic drivers regarding staffing includes quality of care, level of service and patient safety, while tactical drivers include patient volume and acuity, length of stay and clinician output.[7] EC clinician output has traditionally been described as patients consulted per hour (PPH) or in more recent years in some high-income countries as relative value units per hour (RVU/h), a resource based all-encompassing measure used to assist with billing for a clinician's services. The RVU was developed to estimate a clinician's work per patient based on patient acuity and diagnosis, practice costs and malpractice expense for a given intervention or service.[8,9] Several shift, clinician and workload factors affect clinician output and an understanding of these variables and the interaction between them will allow for a better balance between under- and over-staffing, an optimal patient-to-clinician ratio and provide critical information to inform staff rosters and surge planning.[8]

There is however a paucity of literature describing EC clinician output in LMICs and current staffing models are based on anecdotal evidence. The fiscal climate and resource restriction in LMICs further necessitate the need for cost effective staffing models that is based on local evidence. This study aimed to describe clinician output in a district level hospital in the Western Cape in South Africa and how it is affected by different shift, clinician, and workload factors.

Methods

Study design

This was a retrospective cross-sectional study of clinician shifts and patients seen, over three randomly selected four-week periods, using an existing electronic patient registry, to determine the PPH during each clinician shift and how it is affected by various clinician, shift, and workload factors.

Study setting and population

The study was conducted at Mitchells Plan Hospital (MPH), a district level hospital in the Western Cape of South Africa. MPH serves a low- to middle-income population of approximately 650 000 which includes Mitchells Plain, a 45km^2 suburb approximately 32km from Cape Town's city centre, and the greater part of Philippi, a large nearby township. The case mix that presents to the 24-hour EC reflects South Africa's quadruple burden of disease: maternal and child health, HIVAIDS and tuberculosis, non-communicable disease, and violence and trauma. [10]

The EC is managed by four emergency physicians who also manage a second emergency centre about 13 kilometres away. The staffing model utilises a four-week rotating roster which is staffed by four teams of four doctors each. The core team comprises of an emergency medicine registrar, a medical officer and two community service medical officers but teams are often supplemented with interns, extra MPH clinicians and medical officer locums. Clinician consultations are independent but senior staff, (registrars, medical officers and consultants), are available to assist junior staff, (community service medical officers and interns), with clinical queries and patient care. The roster during the week is divided into three shifts with varying lengths and two 12-hour shifts during weekends.

MPH attends to on average of 50 000 patients annually and does not have an intensive care- or high care unit. Patients requiring these services, and those requiring after hour CT scans are transported to a tertiary facility about 30km away with long EC length of stays. There is a 24-hour onsite laboratory and radiological services but no onsite blood bank.

Study sample

This was a descriptive study, and no sample size calculation was performed. A convenience sampling strategy was used which included each shift from three randomly selected non-contiguous four-week periods in 2019. Shifts for all clinicians working in the EC during the study period were eligible for inclusion. Patients who left without completion of treatment were excluded.

Data collection procedure

Deidentified data were exported from the Hospital and Emergency Centre Tracking Information System (HECTIS) registry. The variables collected included the process times of all patients (from time of arrival until the disposition decision is made), the clinician category and the triage category according to the South African Triage Scale. The duty roster allowed for shift duration and category as well as the number of cumulative shifts worked to be collated. Cumulative shifts were defined as shifts beginning on consecutive calendar days. The disposition time was calculated as the time form consultation to disposition. Output was measured as patient per hour (PPH) and calculated as the total number of patients consulted by a clinician divided by the shift duration in hours. Variance within a shift was calculated by dividing the shifts into quarters and calculating the average PPH for each quarter. The average number of boarders in the EC and the total number of patients in the EC during a shift was calculated by averaging two-hourly measures for each shift.

Data analysis

The data set was analysed using IBM SPSS Statistics version 27 and STATA 16. Categorical data were described with summary statistics and proportions. Continuous data that were not normally distributed and displayed as median and interquartile range (IQR). Associations between PPH and shift factors was assessed using the ANOVA and post-hoc adjustments such as the Bonferroni test where appropriate. PPH was not normally distributed and was transformed (squared) to perform robust parametric tests for inference. Statistical significance was defined as a p-value of <0.05. The correlation between PPH and workload metrics was calculated with the Pearson's Rank correlation test. Workload metrics were further categorised into quartiles to allow for the data to be graphically depicted. The data was further analysed for any clinician clustering effect using a multilevel mixed-effects linear regression.

Ethical considerations

Ethical approval was attained from the University of Stellenbosch's Health Research Ethics Committee (HREC S20/01/021) and facility approval achieved through the National Health Research Database website (WC_202006_041). All exported data was further deidentified for patient and clinician prior further analysis.

Results

Of the 1 291 clinician shifts that were eligible for inclusion during the study period of three months, three (0.2%) were excluded due to incomplete information. A total of 1 289 clinician shifts were included in the final analyses. A total of 11841 patients entered the EC of which 9 668 patients were consulted by 111 EC clinicians; 1039 (9%) left before completion of care, 118 (1%) were dead on arrival or demised in the EC, 6339 (53%) were discharged or deferred and 4345 (37%) were referred or transferred for higher care, including patients directly referred and consulted by specific departments. There was no clinician clustering effect found.

Table 1 summarises the characteristics of the shifts that were included for analyses with 55% of the shifts from senior clinicians (registrars and medical officers). The core EC team of four clinicians comprised 68% of all clinician shifts, while the rest consisted out of additional EC staff, locums, or clinicians from other departments. A total of 31% of all shifts were during office hours (08:00-17:00 on weekdays).

Table 1: A summary of shift characteristics (n=1 289)

	n (column %)
Clinician gender	
Male	604 (47)
Female	685 (53)
Clinician category	
Registrar	189 (15)
Medical officer (MO)	511 (40)
Community service MO	397 (31)
Intern	192 (15)
Primary employment	
Emergency Centre	1 090 (85)
Different department	71 (6)
Locum	128 (10)
Team allocation	
Core team	873 (68)
Additional	416 (32)
Shift category	
Week morning (10 hours)	398 (31)
Week afternoon (8 hours)	350 (27)
Weeknight (10 hours)	254 (20)
Weekend day (12 hours)	167 (13)
Weekend night (12 hours)	120 (9)
Weekday	1 002 (78)
Weekend	287 (22)
Public holiday	32 (3)
Cumulative shifts	
1 shift	474 (37)
2 shifts	262 (20)
3 shifts	166 (13)
4 shifts	120 (9)
5 shifts	108 (8)
6 shifts	76 (6)
>6 shifts	83 (7)

Percentages may not add up to 100% due to rounding.

Table 2 summarises the triage acuity according to the South African Triage Sore for each patient per clinician category, as well as the respective disposition times (consultation-to-decision time). Most of the patients (51%) had a high acuity triage score (red and orange). There was an overall increase in the disposition times with increasing level of acuity as per the South African Triage Score. Registrars had the highest proportion of red consultations (7%) but had the longest overall average disposition time (4h22). Proportionally to the number of shifts, medical officers had the highest output with 44% of all consultations while only contributing to 40% of all staff while interns had the lowest output with 10% of all consultations while contributing to 15% of the staff compliment.

Table 2: A description of triage acuity and mean disposition time for each clinician category.

	Total	Registrar	Medical officer	Community service MO	Intern
N (row %)					
Clinicians	111	17 (15)	46 (41)	19 (17)	29 (26)
Shifts	1 289	189 (15)	511 (40)	397 (31)	192 (15)
N (row %)					
Patients	9 668	1 383 (14)	4 262 (44)	3 115 (32)	908 (10)
N (column %)					
Per triage category					
Red	432 (4)	93 (7)	202 (5)	111 (4)	26 (3)
Orange	4 534 (47)	688 (50)	2 061 (48)	1 316 (42)	469 (52)
Yellow	4 163 (43)	505 (36)	1 832 (43)	1 461 (47)	365 (40)
Green	539 (6)	97 (7)	167 (4)	227 (7)	48 (5)
h:m (SD)					
Mean time to disposition	3:00 (4:07)	3:25 (4:22)	3:07 (4:11)	2:37 (3:56)	3:11 (3:59)
Per triage category					
Red	4:45 (5:23)	4:52 (5:08)	5:03 (5:57)	4:00 (3:58)	5:20 (6:37)
Orange	3:52 (4:49)	4:24 (4:58)	3:45 (4:45)	3:43 (4:56)	3:57 (4:27)
Yellow	2:08 (2:54)	2:18 (3:03)	2:21 (3:01)	1:47 (2:41)	2:18 (2:51)
Green	1:09 (1:58)	0:56 (1:12)	1:28 (2:40)	0:59 (1:26)	1:15 (2:26)

Table 3 describes the PPH for various clinician and shifts factors. The overall median PPH was 0.7 (IQR 0.5-1.0). There was significant variance between the clinician categories ($p<0.001$) with medical officers having the highest median PPH (PPH=0.8) and interns the lowest (PPH=0.4). Medical officer locums, as a subcategory had the highest overall PPH (PPH=0.9).

There was a significant difference in PPH between the different combined shift types with the most significance differences noted between the day and night shifts (PPH=0.6 vs 0.9, $p<0.001$). This similar increase in PPH during night shifts was noted for the registrars, and community service medical officer categories. The medical officers had no significant difference between any shift type and were the most consistent. There was also a combined increase in median PPH for weekdays vs weekend shifts (PPH=0.6 vs 0.8, $p=0.021$). Shift duration did not influence the overall PPH ($p=0.228$) with only the community service medical officers showing a significant difference between the 8hr weekday shift and the 12hr weekend shifts (0.6 vs 0.9). There was a significant difference of overall PPH for cumulative shifts with improved PPH for the greater number of cumulative shifts worked, median PPH 0.6 for the 1st shift vs 0.8 for cumulative shifts 5, 6 and greater than 6.

Table 3: A description of PPH for each shift factor and clinician category (median PPH (IQR)).

Shift factors	Combined	Clinician category				Employment Category		
		Registrar	Medical officer	Community service MO	Intern	MPH EC	MPH different department	Locum
Overall	0.7 (0.5-1.0)	0.7 (0.5-0.9)	0.8 (0.6-1.1)	0.7 (0.5-1.1)	0.4 (0.3-0.6)	0.5 (0.4-1.0)	0.4 (0.3-0.8)	0.9 (0.6-1.1)
p-value			<.001					
Shift type								
Weekday	0.6 (0.4-0.9)	0.5 (0.4-0.7)	0.8 (0.4-1.3)	0.6 (0.3-0.8)	0.5 (0.4-0.7)	0.6 (0.4-0.9)		0.8 (0.6-1.2)
Week afternoon	0.6 (0.4-0.9)	0.7 (0.4-0.9)	0.8 (0.6-1.0)	0.6 (0.5-0.9)	0.4 (0.3-0.5)	0.6 (0.4-0.9)	0.4 (0.3-0.6)	0.8 (0.6-1.0)
Weeknight	0.9 (0.6-1.2)	0.9 (0.5-1.1)	0.8 (0.7-1.1)	1.0 (0.6-1.3)		0.9 (1.6-1.2)		0.9 (0.8-1.2)
Weekend day	0.7 (0.4-1.0)	0.8 (0.5-0.9)	0.8 (0.5-1.0)	0.8 (0.5-1.3)	0.4 (0.2-0.6)	0.7 (0.4-0.9)	0.3 (0.1-0.8)	0.9 (0.6-1.0)
Weekend night	0.9 (0.7-1.1)	0.8 (0.6-1.0)	0.9 (0.6-1.1)	1.0 (0.6-1.3)		0.9 (0.6-1.0)	1.0 (0.8- __)	1.0 (0.7-1.4)
p-value	<.001	<.001	0.05	<.001	<.001			
Week	0.6 (0.4-1.0)	0.6 (0.4-0,9)	0.8 (0.6-1,1)	0.7 (0.5-1.1)	0.4 (0.3-0.5)	0.6 (0.4-1.0)	0.4 (0.3-0.6)	0.8 (0.6-1.1)
Weekend	0.8 (0.5-1.1)	0.8 (0.6-1.0)	0.9 (0.6-1.0)	0.9 (0.5-1.2)	0.4 (0.2-0.6)	0.8 (0.5-1.1)	0.3 (0.1-0.9)	0.9 (0.7-1.2)
p-value	0.021	0.058	0.40	.011	0.37			
Shift duration								
8 hours	0.6 (0.4-1.0)	0.6 (0.4-0.9)	0.9 (0.6-1.2)	0.6 (0.5-0.9)	0.4 (0.2-0.6)	0.6 (0.4-1.0)	0.4 (0.3-0.6)	0.8 (0.6-1.0)
10 hours	0.7 (0.5-1.0)	0.7 (0.5-1.0)	0.7 (0.5-1.0)	0.8 (0.4-1.1)		0.7 (0.4-1.0)		0.9 (0.6-1.1)
12 hours	0.8 (0.5-1.1)	0.8 (0.6-1.0)	0.9 (0.5-1.0)	0.9 (0.5-1.2)	0.4 (0.2-0.6)	0.8 (0.5-1.1)	0.8 (0.1-0.9)	0.9 (0.6-1.2)
16 hours	0.5 (0.4-0.7)				0.5 (0.4-0.7)	0.5 (0.4-0.7)		
p-value	0.228	0.19	<0.001	0.012	0.05			
Cumulative shifts								
1 shift	0.6 (0.4-1.0)	0.7 (0.4-1.0)	0.9 (0.6-1.1)	0.6 (0.4-1.0)	0.4 (0.3-0.5)			
2 shifts	0.7 (0.5-1.0)	0.7 (0.5-0.9)	0.8 (0.6-1.1)	0.6 (0.5-1.1)	0.5 (0.3-0.6)			
3 shifts	0.6 (0.4-1.0)	0.6 (0.4-0.9)	0.7 (0.4-1.2)	0.6 (0.3-1.0)	0.5 (0.4-0.8)			
4 shifts	0.7 (0.4-0.9)	0.6 (0.3-1.1)	0.6 (0.4-1.0)	0.7 (0.5-1.0)	0.4 (0.4-0.7)			
5 shifts	0.8 (0.5-1.1)	0.8 (0.5-0.9)	0.9 (0.6-1.5)	0.8 (0.6-1.2)	0.5 (0.4-0.7)			
6 shifts	0.8 (0.6-1.1)	0.6 (0.5-1.1)	0.8 (0.8-1.0)	1.0 (0.6-1.3)	0.5 (0.4- __)			
>6 shifts	0.8 (0.6-1.2)	0.9 (0.6-1.1)	0.8 (0.6-1.0)	1.0 (0.5-1.3)	0.5 (0.4- __)			
p-value	<0.001	0.69	0.05	0.002	0.15			
Intra shift variance								
1st quarter	1.0 (0.5-1.5)	1.0 (0.5-1.5)	1.0 (0.8-1.6)	1.2 (0.8-1.6)	0.5 (0.3-1.0)	1.0 (0.5-1.5)	0.5 (0.0-1.0)	1.0 (0.7-1.6)
2nd quarter	0.8 (0.5-1.2)	0.8 (0.4-1.2)	1.0 (0.5-1.5)	0.8 (0.4-1.3)	0.5 (0.3-0.7)	0.5 (0.5-1.3)	0.5 (0.0-1.0)	1.0 (0.7-1.5)
3rd quarter	0.5 (0.3-1.0)	0.5 (0.3-1.0)	0.7 (0.4-1.0)	0.5 (0.3-1.0)	0.5 (0.0-0,5)	0.5 (0.3-1.0)	0.5 (0.0-1.0)	0.7 (0.4-1.2)
4th quarter	0.3 (0.0-0.7)	0.3 (0.0-0.7)	0.4 (0.0-0.8)	0.4 (0.0-0.7)	0.0 (0.0-0.3)	0.0 (0.0-0.5)	0.0 (0.0-1.0)	0.4 (0.0-1.0)

With regards to the intra-shift variance of clinician output, a significant overall decline was noted from the first (PPH=1.0) to the last quarter (PPH=0.3). Community service medical officers had the highest PPH in the first quarter (PPH=1.2) while medical officers showed no decline (PPH=1.0) during the first and second quarters. Interns showed no decline in the first three quarters (PPH=0.5) but then had a median of 0 during the last quarter of their shifts. Figure 1 depicts the overall intra-shift variance graphically.

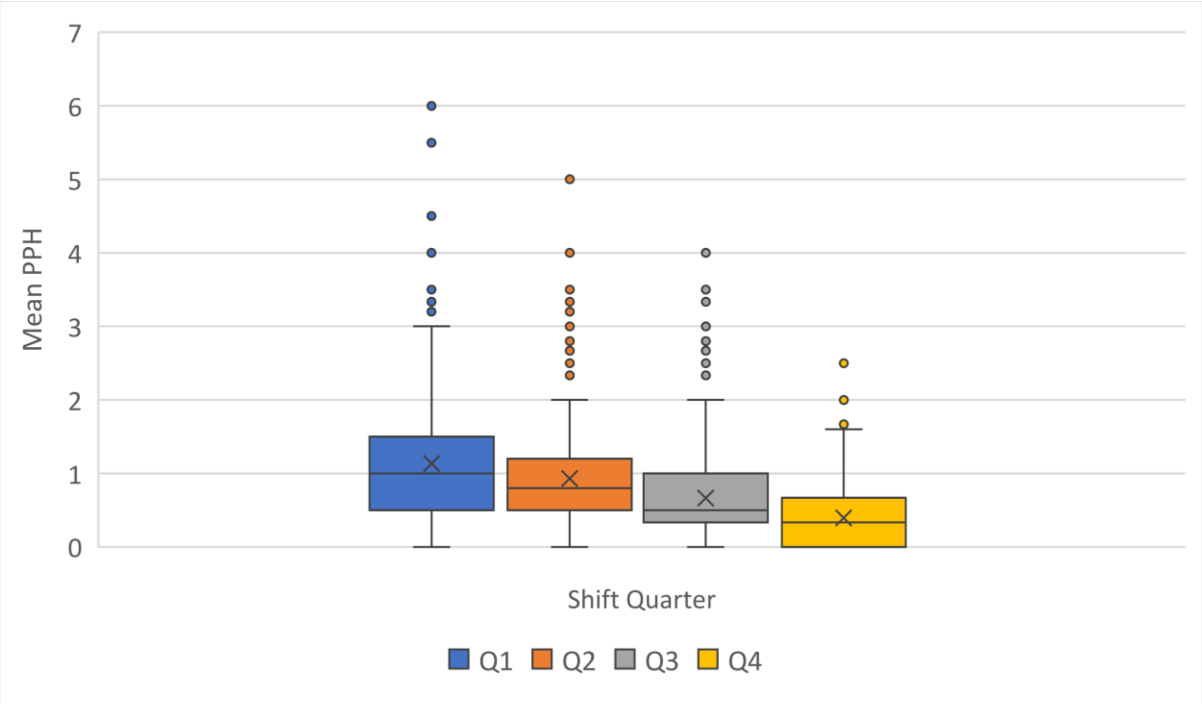

Figure 1: A description of the overall PPH for each shift quarter (X=med).

The association between EC workload metrics and overall PPH is depicted in Figure 2. A significant positive association was found between the overall PPH and the number of patients waiting at the beginning of the shift (Coef. 0.003, p<0.001, 95%CI 0.002 to 0.004) and new patients arriving during a shift (Coef. -0.002, p<0.001, 95%CI -0.002 to -0.001). Average numbers of boarders in the EC during the shift was significantly negatively associated with PPH (Coef. -0.003, p=-0.003, 95%CI -0.005 to -0.002). There was no significant association for PPH and total number of patients in the EC during a shift (Coef. 0.0002, p=0.69, 95%CI 0.0008 to 0.001).

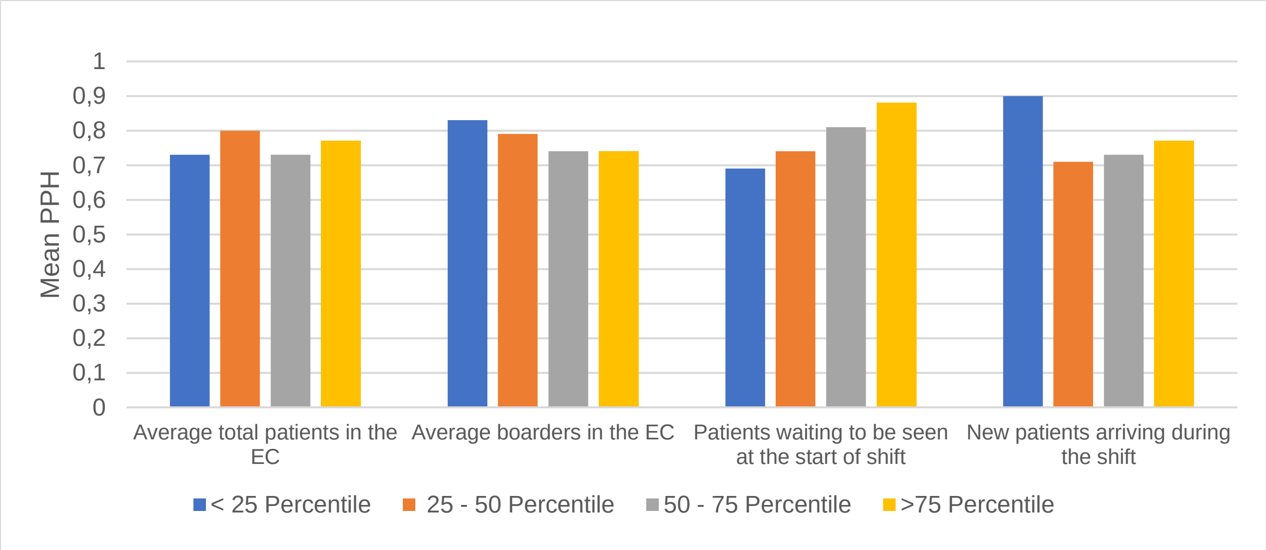

Figure 2: A bar chart displaying the mean PPH for each workload metric per quartile.

Discussion

This study, being one of the first to describe clinician output in a LMIC, shows a significantly lower overall PPH as described in high-income countries. The American College of Emergency Physicians claims that even though PPH rates as high as 2.3 - 2.8 have been recognised in the past, considering the increased workload and patient complexity and acuity, customer expectations, workload factors such as crowding and boarders, and risk management a PPH of 1.8 to 2.8 is probably more realistic currently.[7] This is around 2.5 times higher than the overall PPH of 0.7 described in this study. Individual clinician's output, however, can be influenced by several community factors including burden of disease, age, demographics, hospital factors including level of care provided by the hospital, onsite resources, inpatient bed availability, EC factors including staffing, referral pathways, capacity and clinician factors.[9] It is also imperative to realise that clinician output does not reflect overall productivity or an individual clinician's value contribution as there are certain tasks and functions that are intangible and difficult to quantify, for example nursing intubated patients in the EC for lengthy periods. The use of PPH to quantify clinician output is therefore questionable and probably not appropriate to estimate value but rather useful and necessary for staff scheduling and surge planning. Even though RVUs has become a more commonly used metric to measure clinician output as it helps to control for patient complexity, both PPH and RVUs are imperfect measures as they fail to incorporate the unmeasurable contributors to patient care.[8]

Literature has shown that clinician output is higher during shorter shifts (8-hour vs 12-hour), and during daytime.[11,12] Pines et al. (2020) showed perceived workload and operational stressors such as patient complexity and acuity, workload factors such as boarders and new patient arrivals, to be higher overnight.[13] It is however interesting to find that the clinicians' output in this study was not affected by shift length and were in fact significantly higher during weekend shifts and night shifts. Jeanmonod et al. (2009), found that senior (third year) residents had higher PPH rates on night shifts as opposed to junior residents, presumably due to the improved ability to process the lower acuity patient that presented overnight.[14] The reasons for the higher PPH rate during night shifts in this study is likely multifactorial and requires further assessment.

Clinician role has been recognised as a driver of productivity and output.[8] At MPH, locum clinicians, who are exclusively involved in patient care and generally assigned to lower acuity areas, were shown to have the highest output over MPH EC clinicians, who also attend to administrative (non-clinical) tasks, patient flow and complex patient hand overs. Joseph et al. (2018) found that residents who received more patient hand overs during shift change, tend to consult fewer patients during their shift. This was significant for the second-year residents who generally also attended to higher acuity patients and resulted in a much lower output.[15] Brennan et al. (2007) also postulated that the lower increase in productivity between senior residents' years was due to the increased unmeasurable non-clinical responsibilities.[16] Which could potentially explain why EC clinicians had lower output than locums, and that registrars had lower output than the medical officers.

There was an obvious decline in output during the course of a shift, in keeping with previous research [12,14], which plunged in the last quarter with PPH declining to zero for the intern group. This is an important finding to consider when scheduling clinicians and considering shift length and overlap, peak patient presentation times and shift scheduling models. [8] Even though output decreased within a shift, there was a significant increase shown with consecutive shifts. Jeanmonod et al. (2009) proposed this to be due to an increasing familiarity with the environment and patient.[17] The thought that environment familiarity improves productivity may further be illustrated by the fact that in our study medical officers and community service medical officers, who generally stay in the department for a longer period, produced a higher overall PPH than registrars and interns, who generally rotate through the EC for shorter periods. Similarly, Joseph et al. (2018) showed improved intern productivity with time spent in the EC rather than their year of training.[18]

Although the average total patient volume in the EC did not have a significant impact on clinician output in both this study and in previous studies[14], there was a significant negative correlation between the average number of boarders in the EC and clinician output. Access block and disruptions to the outflow of patients from the EC has been shown to drain hospital resources and impair the EC's ability to care for new seriously ill or injured patients.[19] The presence and number of boarders have been shown to be the most consistent cause of delays in EC patient care with access block having a significant relationship to EC crowding and EC length of stay.[3] There was however a positive correlation between clinician output and patients waiting to be seen at the start and to a lesser extent new patients arriving during a shift.

There is a paucity of data in LMICs describing emergency clinician output and the results of this study can be used to generate hypotheses and could form the basis for future studies. Even though this study was one of the first in a LMIC, the significance of the results could be limited by the fact that this was a single centre study and potentially only reflecting local practice. Vukmir et al. (2010) showed that PPH was lower for smaller centres seeing 1 500 or less patients per annum compared to larger centres that saw 45 000 or more patient per annum.[20] Another limitation is that not all factors that could have influenced clinician output were assessed, such as clinician experience (years post qualification for registrars and medical officers) and time since employment (familiarity with the EC environment). Confounding factors should also be modelled in future research.

Future research should assess potential reasons for the low PPH described and subsequent studies should focus on the cost-effectiveness of quality improvement interventions. A multicentre study should confirm whether the results are generalisable and determine the key drivers behind clinician output in a low resource setting.

Conclusion

This study describes a relatively low clinician output as compared to evidence from high-income countries and has highlighted several associations with various shift, clinician, and workload factors. Clinician output was negatively associated with the number of boarders in the EC but positively associated with the number of patients waiting at the start if each shift. Both PPH and RVUs are regarded as imperfect measures of productivity as they fail to incorporate the unmeasurable contributions to patient care and non-clinical workload. The results from this study will form the basis of quality improvement interventions to improve patient throughput and will inform staff scheduling and surge planning strategies.

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Dissemination of Results

The results have been disseminated to the respective Emergency Centre and Hospital managers, as well as to the Faculty of Emergency Medicine Cape Town.

Authors' Contributions

Authors contributed as follow to the conception or design of the work (CH and MH); the acquisition (CH and MH), analysis (CH, MH, and MM), or interpretation (CH, MH, and MM) of data for the work; and drafting the work (MH) or revising it critically for important intellectual content (CH, MH, and MM): MH contributed 45%; CH 35 %; and MM 20%. All authors approved the manuscript to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interests

Both CH and MM are editors of the African Journal of Emergency Medicine. CH and MM were not involved in the editorial workflow for this manuscript. The African Journal of Emergency Medicine applies a double blinded process for all manuscript peer reviews. The authors declared no further conflicts of interest.

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Part B: Addenda

Addenda 1: Author Guidelines – African Journal of Emergency Medicine

Available at:

https://www.elsevier.com/journals/african-journal-of-emergency-medicine/2211-419X/guide-for-authors

Addenda 2: Research Proposal

Emergency clinician output in a district hospital Emergency Centre: a cross-sectional analysis

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This study is in the partial fulfilment of the Master of Medicine (Emergency Medicine) degree

Declaration

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

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Abbreviations

ACEP	American College of Emergency Physicians
EC	Emergency Centre
EM	Emergency Medicine
CI	Confidence Interval
CSMO	Community service Medical Officer
HECTIS	Hospital and Emergency Centre Tracking Information System
HICs	High-income countries
IQR	Interquartile range
LMICs	Low- to middle-income countries
MLP	Mid-level Provider
MO	Medical Officer
MPH	Mitchell's Plain District Hospital
NHRD	National Health Research Database
PPH	Patients seen Per Hour
RSA	Republic of South Africa
RVU	Relative Value Unit
SATS	South African Triage Score
SUN HREC	Stellenbosch University Health Research Ethics Committee
USA	United States of America

Abstract

Introduction

Overcrowding and poor throughput is a significant problem faced by most Emergency Centres (EC) worldwide. Several factors influence EC throughput, including clinician output or productivity. Clinician output is classically measured as patients seen per hour (PP/H). Several studies have looked at clinician output in high-income settings, but there is however limited data on clinician output in low- to middle-income country (LMIC) such as South Africa, with roster compilation usually based on anecdotal evidence. The aim of this study is to assess clinician output at a district level emergency centre, and how it varies depending on type of shift, clinician category and patient flow factors?

Methodology

This study will be a cross sectional analysis, collecting retrospective data from an existing electronic database. Data will be collected over three non-contiguous randomly selected four-week cycles within a given period from Mitchells Plain Hospital's (MPH) electronic data base, HECTIS. Based on the current number of patients seen at MPH this will give an expected sample size of 10500 patients and 275 shifts. Clinician output will be compared to different shift and clinician factors. Correlational assessments will also be done with various patient flow metrics.

Ethical Considerations

This will be a retrospective analysis of routinely collected data therefore attaining individual consent will be impractical. The risk to patient and provider is minimal as all analysed and published data will be fully deidentified; for the reason a waiver of informed consent will be requested. The overall outcome is expected to benefit both patient and provider. Stellenbosch University Health Research Ethics Committee (SUN HREC) approval will be applied for and thereafter approval from the National Health Research Database (NHRD).

Conclusion

This study will provide some information on current clinician output and how clinician output is affected by certain EC flow, provider and shift factors; with the hope that this knowledge can improve EC staffing and scheduling which is currently based on anecdotal evidence. Describing clinician output in a LMIC is also a steppingstone to understanding EC throughput from which a multitude of quality improvement projects can stem.

Introduction

Background

Overcrowding in emergency Centres (EC) is a recognised global challenge. The American College of Emergency Physicians (ACEP) defines overcrowding in their policy statement as "when the identified need for emergency services exceeds available resources for patient care in the EC, hospital or both"; they further go on to report a number of adverse events related to overcrowding including increased patient morbidity and mortality, longer admission length of stays, decreased EC staff satisfaction and increased costs [21–23]. Low to middle income countries (LMICs) such as the Republic of South Africa (RSA) are not exempt from the problem of overcrowding in the EC, one study conducted in Khayelitsha Hospital, a district level hospital in the Western Cape of South Africa, showed bed occupancy in the EC to be between 128 -132% depending on the time of day[4]. It can further be postulated that overcrowding in LMICs may be worse than in high income countries (HICs) such as the United States of America (USA) due to known health care worker shortages and increased burden of disease. The World Health Organisation (WHO) stated in 2019 that around 80% of LMICs had fewer than 10 medical doctors per 10 000 population with the RSA having 9.1/10000 medical doctors per population compared with 25.95/10000 in the USA[5,6].

EC patient flow, a major contributor to overcrowding, can be described under three headings: input, output and throughput; these referring to patients arriving at the EC, from arrival to disposition, and from disposition to exit from the EC respectively. Throughput essentially evaluate the bottlenecks within the EC with inadequate staffing and resulting delay to consultation being a contributing factor [22]. In addition to inadequate staffing is provider productivity and provider output – how many patients a provider consults per time period.

Clinician output is key to EC efficiency and a vital part of EC patient throughput. Clinician output also known as physician productivity has traditionally been measured as the number of patients seen per hour (PPH). It has been noted that only looking at PPH does not incorporate the difference in complexity of individual patients which could influence the processing speed of the clinician. Relative value units per hour (RVU/h) has been proposed and used as a more encompassing way to measure clinician output. The Relative Value scale and from it the Relative Value Unit (RVU) was developed by a study out of Harvard as a resource based all-encompassing unit to assist with billing for a clinician's services. No such unit or billing tool exist or is commonly utilised in the RSA however one study comparing PPH and RVU/h when looking at emergency resident productivity showed significant correlation between the two extrapolating that PPH is as effective as RVU/h when measuring efficiency [24].

One of the targets when optimising throughput is to have productive staff – maintaining a reasonable and sustainable clinical output to manage the patient load whilst avoiding clinician burn out. A number of factors have been considered to affect clinician output and productivity by the ACEP highlighted as: community factors including age and demographics of the community, health and other resources available to the community outside the hospital/EC; hospital factors including hospital demographics, efficiency of individual departments and the attitude of the hospital towards managing unscheduled patients; EC factors including EC demographics, available resources and support staff and experience of the clinicians; [25] Another factor to consider is how scheduling, including accumulated hours on shift, time of day and number of consecutive hours worked, would affect clinician output. Existing studies looking at clinician output have looked at how output in terms of PPH or RVU/hr have varied with experience, patient acuity, patient load, handover load, time of day, accumulative hours during a shift, number of consecutive shifts in a row and number of hours worked per annum (10-21) Having data on physician output has further allowed the USA to develop the Emergency Department Benchmarking Alliance that provides members with a database of demographic and performance metrics including expected productivity in terms PPH for ECs of different patient volume. This is hoped to help with expected EC staffing and to gauge how your EC is faring in terms of clinician output as a marker of functionality and overall patient care. [30] All of the data and studies found regarding clinician output were conducted in a HIC and more specifically the USA with no research found extending to LMIC.

Motivation

Describing what the current clinician output is, over and above helping to understand EC throughput and improve EC staffing and scheduling, can open up the doors to a number of quality improvement projects. Some examples of quality improvement projects thus far are studies that have looked at: how the addition of scribes and electronic health records have improved clinician output; how productive the utilisation of mid-level providers (MLP) are in an emergency setting.[31–33] RSA has recently introduced the clinical associate program, an MLP equivalent, with its first graduates in 2011, in the hope of assisting with the shortage of physicians in district and primary health care.[34] Looking at clinician output or more specifically clinical associate output and how it compares could assist in evaluating their benefit in an RSA or LMIC setting. Evaluating clinician output in a LMIC could also assist in understanding and evaluating further bottlenecks affecting throughput, output and eventually EC overcrowding. Categories of clinicians working in the EC are either interns, community service office, medical offices or emergency medicine (EM) registrars who generally have increasing years of experience as a clinician and seniority from intern to EM registrar. There may be similar years of experience between a medical officer and EM registrar however the seniority and academic pressure is generally higher in the EM registrar group who are training to become EM specialists. Currently rostering and staff scheduling is designed around anecdotal evidence, further understanding how a clinician's output is affected by their rostered hours and how this differs with clinician experience and seniority could assist in designing a roster that optimizes provider productivity. These are just a few examples where understanding clinician output in a LMIC could assist with further quality improvement and potentially decreasing the problem of EC overcrowding.

LMIC health care differs vastly from HIC in terms of both community and hospital resources and demographics. EC Overcrowding is not isolated to HIC and can even be postulated to be worse in LMIC. With this in mind it seems imperative that further studies are needed looking at factors affecting overcrowding in a LMIC environment; one factor to consider is clinician output and is effects on EC throughput. Describing clinician output and how it varies with clinician, patient and scheduling factors has the added benefit of assisting EC operation with optimal scheduling and staffing (rostering) and will provide a seed from which further quality improvement projects can grow.

Aim

For all adult patient consultations in an emergency centre, what is the clinician output and how does this vary depending on type of shift, clinician category and patient flow factors?

Objectives

Primary objective:

To measure and compare clinician output between clinician categories and how this is impacted by different shift factors.

- Clinician categories:
  - Intern
  - Community Service Officer
  - Medical Officer
  - Emergency Medicine Registrar
- Shift factors:
  - Length of shift
  - Type of shift (day, afternoon or night shift)
  - Day of the week
  - Number of cumulative shifts
  - Within a shift (variance of clinician output within a shift)

Secondary objective:

To assess the correlation between clinician output and the following patient flow metrics:

- Number of patients waiting to be seen at the beginning of the shift (acute patient load at the beginning of the shift)
- Number of new patients arriving during the shift
- Average number of patients awaiting inpatient beds (boarding) during a shift
- Average total number of patients in the EC (crowding) during a shift including patient awaiting to be seen, awaiting a disposition plan and boarding patients.

Methodology

Study Design

This study will be a cross sectional analysis, collecting retrospective data from an existing electronic database.

Study setting

Facility: This study will investigate all adult patient consultations at Mitchells Plain Hospital (MPH), a district level hospital in the Western Cape of South Africa. MPH serves Mitchells Plain, a 43,76km^2 suburb of the Western Cape stretching from False Bay to Khayelitsha. Mitchell's Plain Hospital is approximately 32km from Cape Town's city centre and serves a population of approximately 750 000 - 800 000, which includes the population of Mitchells Plain and the greater part of Philippi, a large nearby township. The demographics of Mitchells Plain comprises of low- to middle-income families of which 90% are coloured, and Philippi which is a low-income community that comprises of 90% black residents. MPH's EC attends to patients of all demographics with a broad variety of medical and surgical pathologies. Adult and paediatric patients are consulted in different treatment areas, and both are staffed by emergency clinicians and supervised by specialist emergency physicians.

Staffing: Emergency clinicians are divided into teams of four, that generally comprises of two community service medical officers and a senior (either a medical officer and an emergency medicine registrar, or two medical officers). Each team is allocated to a generic revolving 4-week cyclical roster. There are three shifts per weekday and two per weekend day with one team allocated per shift. The team will have to cover both the adult and paediatric EC, and there are additional staff allocated to work during certain shifts.

A summary of the shift layout is depicted below in Table 1.

Table 4: Shift layout

	Shift	Time	Actual shift length (Hours)	Shift quarter length (Hours)
Weekday	Day	8:00 – 18:00	10	2.5
	Afternoon	14:00 – 22:00	8	2
	Night	22:00 – 08:00	10	3
Weekend	Day	8:00 – 20:00	12	3
	Night	20:00 – 08:00	12	3

Study Population

Inclusion Criteria:

1. **Provider**: All shifts of clinicians allocated to work in the emergency centre during the study period including interns, community service medical officers, medical officers and emergency medicine registrars will be eligible for inclusion.
2. **Patient**: All adult patients consulted by an emergency medicine provider during the study period.

Exclusion Criteria:

1. **Provider:** Shifts of clinicians from subspecialties that may have fast tracked or seen direct referrals patients in the emergency department prior to them being seen by an emergency department doctor. Emergency medicine consultants will be excluded as they not part of the emergency clinician shift roster and do not routinely consult patients.
2. **Patient:** All paediatric patients and any adult patient not initially consulted by an emergency medicine provider.

Data collection procedure

The data collection procedure will be described in two parts**:** part one – analysing clinician output and how it is affected by clinician category and various shift factors, and part two – assessing the correlation between clinician output and selected patient flow metrics.

Part One

Deidentified data will be exported from the electronic database, Hospital and Emergency Centre Tracking Information System (HECTIS) onto a spreadsheet. HECTIS is a reasonably new registry that is in use in a few emergency centres across the Western Cape. Routine clinical data are collected for each patient that enters the EC and HECTIS aims to replace the old paper-based patient register that most ECs use. A patient gets registered on the database as soon as the patient registers an emergency centre visit. Required data will be imported from HECTIS after ethical and institutional approval has been obtained. The necessary calculations will be performed, in conjunction with information from the clinician roster. The clinician rosters for the chosen study period will be accessed from an existing saved archive. Required roster information will then be exported into the dataset. During this process clinician will be divided into clinician category based on researcher knowledge about the provider; once allocated to a category the provider will be fully deidentified and this deidentified dataset used for further analysis. The refined dataset will then be exported to a statistical software package.

- A patient consult will be defined as a patient encounter on HECTIS where a clinician has initiated care on a patient, whether or not a diagnosis or disposition was entered.

- Clinician output will be expressed as patient-per-hour (PPH) and defined as patient consults per hour.
- Cumulative shifts will be defined as shifts beginning on consecutive calendar days.
- Variance within a shift will be calculated by dividing the shifts into equal quarters and comparing the average PPH for each quarter (see table 1 above).

Part Two

To calculate the correlation between clinician output and patient flow metrics, the following data will be extracted from HECTIS:

- The number of patients waiting to be consulted at the start of each shift
- The number of boarders in the EC during the shift – 2-hourly values will be extracted for each shift and the average calculated.
- The total number of patients in the EC during the shift – values will be extracted for each shift and the average calculated for each quarter.
- The number of new patients that arrived at the EC during the shift

Data Safety and Monitoring

All files containing data including clinician rosters will be stored on the principal investigator's personal password protected laptop. The file will also be password protected for added security. This file will also be stored on the Researcher's (Mary Hoffe) University of Stellenbosch One Drive account, a secure cloud service that requires a password to access. Supervisors will have access to the files from the One Drive account. A backup of all data files will be performed on a cloud service and on an external hard drive, after the data collection is completed. The external hard drive will be kept in a locked cabinet in the access-controlled offices of the Division of Emergency Medicine at the University of Stellenbosch. Data will be de-identified and saved without personal or identifying information, once the data collection phase is completed. No personal information from patients are necessary, as the study analysis clinicians' output and not clinical management.

Data Analysis

Please refer to Appendix 1 for a detailed data analysis plan. Categorical data will be described with summary statistics and proportions/percentages and compared with the use of Fisher's exact or Chi^2 tests, depending on the variable characteristics. Central tendency and spread for normally distributed variables will be described as averages and standard errors, while medians and interquartile ranges will be used or non-normally distributed data. Comparison of averages of continuous variables between more than two categories will be calculated by ANOVA. Correlation between continuous variables will be calculated with the help of Pearson or Spearman's coefficient and data will be graphically depicted on scatter plots. 95%

Confidence intervals (CI) will be provided where applicable and statistical significance will be defined as $p<0.05$. Data will be analysed in consultation with the Stellenbosch University Division of Epidemiology and Biostatistics using IBM SPSS Statistics version 25 or STATA.

Sample Size

This is a purely descriptive study so no formal sample size or power calculation was performed - a representative convenience sample size will thus be used. We have chosen to conduct this study over three randomly selected non-contiguous four-week cycles within a given period, which will give us a predicted sample size of 275 shifts and 10500 patients based on the current roster and MPH EC's current monthly patient load respectively. Non-contiguous four-week cycles are chosen to try decrease any time of year bias and improve anonymity of the physicians.

Ethical Considerations

Risks and Benefits

Risk: All data in the data set will be fully deidentified to alleviate any risk for both the patient and provider. Various safeguards are in place to protect the identity of the patient and provider included in this study. Please refer to the data safety section above.

Benefits: This study hopes to provide information to assist with optimising EC staffing and scheduling with the eventual outcome of balancing the workload, decreasing the work burden and improving EC throughput and overcrowding. These outcomes are expected to benefit both the patient and provider.

Informed Consent

The research involves no more than minimal risk to the participants and we therefore request a waiver of informed consent. As this will be a retrospective analysis of routinely collected data, taking individual consent will be impractical. There is no interest in individual patients, nor individual healthcare personnel. Further three non-contiguous randomised four-week samples will be selected during a given period to further decrease physician anonymity.

Privacy and Confidentiality

As stated above all patients and providers will be deidentified in the data set and thus during any form of analysis and publication.

Reimbursement and Insurance

No patient or provider will be reimbursed for participation in this study.

Strengths and Limitations

Strengths

There is a paucity of data regarding provider output and its variance and correlation with patient flow metrics in LMICs. This study will provide valuable information that will assist in improved staffing models and rostering ultimately leading to improved waiting times and quality care. This is a descriptive study using easily accessible data from an existing EC electronic patient tracking system.

Limitations

This study analyses data from a single site and external validity may be questioned. The staffing model and provider breakdown is however similar to many emergency centres and results are expected to be generalisable. Date and time information, for when the patient was initially seen, collected from HECTIS are dependent on correct/timeous input by providers, who are required to place the patient under their name on the system when they start seeing a new patient, the date and time that this is done is then automatically recorded on HECTIS and will be used in our analysis – unpublished audits suggest that compliance and accuracy is very good.

Dissemination Plan

A published article in an open access peer reviewed journal is anticipated. We would like to make our results available to other LMIC EC managers with the hope that a better understanding of their providers potential productivity will help to improve staffing and rostering. Results will also be shared locally with hospital and EC managers, as well as the faculty of emergency physicians.

Project Timeline

Table 5 : Project Timeline

2019/2020	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
EMDRC	x	x	x									
Ethics				x	x	x						
WCG Approval						x	x	x				
Data Collection								x	x			
Analysis									x	x	x	
Write up	x											x
Submission		x										

Resource Utilisation and Budget

Table 6: Project Budget

September 2019 – July 2020		
Resources		
• Hardware	Laptop, cell phone	Free
• Software	Microsoft Office, Statistical Software	Free
• Printing	printing, copying, binding	R200
• Consumables	Data, airtime	R500
Specialist Services		
• Statistician	2 x 1-hour meetings	Free
Travel		
• Stellenbosch Medical School to MPH	5 X 20 km trips @ R1,65/km (SARS Rate)	R165
Total Cost		R865

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Appendices

Appendix 1: Data analysis plan

Table 7: Data analysis plan

Objective	Variables	Variable type	Data source	Analysis
Primary objective: To measure and compare clinician output between clinician categories and how this is impacted by different shift factors.	Outcome variable: Clinician output (patient per hour rate (PPH) for each Clinician category) Predictor Variable: 1. Length of shift 2. Type of shift 3. Day of week 4. Number of cumulative shifts 5. Variance with a shift	PPH = Numerical continuous 1. Categorical nominal 2. Categorical nominal 3. Categorical nominal 4. Categorical ordinal 5. Categorical nominal	HECTIS: direct data extraction - calculations will be performed in Excel before exporting the data to SPSS.	1. ANOVA* 2. ANOVA* 3. ANOVA* 4. ANOVA* 5. ANOVA* *or non-parametric equivalent
Secondary objective: To assess the correlation between clinician output and patient flow metrics:	Outcome Variable: Clinician output (PPH) Predictor Variable: 1. Number of patients waiting to be seen at the beginning of the shift 2. Number of new patients arriving during the shift 3. Average number of patients awaiting inpatient beds during a shift 4. Average number of patients in the EC during a shift	PPH = numerical continuous 1. Numerical discreet 2. Numerical discreet 3. Numerical discreet 4. Numerical discreet	Direct extraction from HECTIS.	Scatter plot Spearman's rank correlation coefficient (not-normally distributed data)

Addenda 3: Ethics Approval Letters

UNIVERSITEIT
STELLENBOSCH
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Approval Notice

New Application

24/06/2020

Project ID:11824

HREC Reference No: S20/01/021

Project Title: Emergency clinician output in a district hospital Emergency Centre: a cross-sectional analysis

Dear Dr Mary Hoffe

The **New Application** received on 29/01/2020 09:04 was reviewed by members of **Health Research Ethics Committee** via **expedited** review procedures on 24/06/2020 and was approved.

Please note the following information about your approved research protocol:

Protocol Approval Date: 24 June 2020

Protocol Expiry Date: 23 June 2021

Please remember to use your Project ID 11824 and Ethics Reference Number S20/01/021 on any documents or correspondence with the HREC concerning your research protocol.

Please note that the HREC has the prerogative and authority to ask further questions, seek additional information, require further modifications, or monitor the conduct of your research and the consent process.

After Ethical Review

Translation of the informed consent document(s) to the language(s) applicable to your study participants should now be submitted to the HREC.

Please note you can submit your progress report through the online ethics application process, available at: Links Application Form Direct Link and the application should be submitted to the HREC before the year has expired. Please see *Forms and Instructions* on our HREC website (www.sun.ac.za/healthresearchethics) for guidance on how to submit a progress report.

The HREC will then consider the continuation of the project for a further year (if necessary). Annually a number of projects may be selected randomly for an external audit.

Provincial and City of Cape Town Approval

Please note that for research at a primary or secondary healthcare facility, permission must still be obtained from the relevant authorities (Western Cape Departement of Health and/or City Health) to conduct the research as stated in the protocol. Please consult the Western Cape Government website for access to the online Health Research Approval Process, see: https://www.westerncape.gov.za/general-publication/health-research-approval-process. Research that will be conducted at any tertiary academic institution requires approval from the relevant hospital manager. Ethics approval is required BEFORE approval can be obtained from these health authorities.

We wish you the best as you conduct your research.

For standard HREC forms and instructions, please visit: Forms and Instructions on our HREC website https://applyethics.sun.ac.za/ProjectView/Index/11824

If you have any questions or need further assistance, please contact the HREC office at 021 938 9677.

Yours sincerely,

Mrs. Brightness Nxumalo
HREC 2 Coordinator

National Health Research Ethics Council (NHREC) Registration Number:

REC-130408-012 (HREC1)•REC-230208-010 (HREC2)

Federal Wide Assurance Number: 00001372
Office of Human Research Protections (OHRP) Institutional Review Board (IRB) Number:

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5th Floor, Norton Rose House,, 8 Riebeek Street, Cape Town, 8001
www.capegateway.gov.za)

REFERENCE: WC_202006_041
ENQUIRIES: Dr Sabela Petros

Francie van Zijl Drive
Tygerberg
7505
Cape Town
South Africa

For attention: Dr Mary Elizabeth Hoffe, Dr Clint Hendrikse, Mr Michael Mccaul

Re: Emergency clinician output in a district hospital Emergency Centre: a cross-sectional analysis

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.
Please contact the following people to assist you with any further enquiries in accessing the following sites:

Mitchells Plain Hospital	**Dr Jacek Marszalek**	**021 377 4782**

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interrupted.
2. Researchers, in accessing provincial health facilities, are expressing consent to provide the department with an electronic copy of the final feedback (**annexure 9**) within six months of completion of research. This can be submitted to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).
3. In the event where the research project goes beyond the *estimated completion* date which was submitted, researchers are expected to complete and submit a progress report (**Annexure 8**) to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).
4. The reference number above should be quoted in all future correspondence.

Yours sincerely

DR M MOODLEY
DIRECTOR: HEALTH IMPACT ASSESSMENT
DATE: 22/10/2020
CC