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## Use of the SONET Score to Evaluate Urgent Care Center Overcrowding

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1 Title Page:

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14 Key words: Urgent care center, Crowding, Tool, Patient care outcome

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# 17 Use of the SONET Score to Evaluate Urgent Care Center Overcrowding

## 18 Abstract

19 **Objectives:** To derive a tool to determine Urgent Care Center (UCC) crowding and investigate the association  
20 between different levels of UCC overcrowding and negative patient care outcomes.

21 **Design:** Prospective pilot study

22 **Setting:** Single center study in USA.

23  
24 **Participants:** 3,565 patients that registered at UCC during the 21 day study period were included. Patients who had  
25 no overcrowding statuses estimated due to incomplete collection of operational variables at the time of registration  
26 were excluded in this study. 3,139 patients were enrolled in the final data analysis.

27  
28 **Primary and secondary outcome measures:** A crowding estimation tool (SONET: Severely overcrowded,  
29 Overcrowded, and Not overcrowded Estimation Tool) was derived using the linear regression analysis. The average  
30 length of stay (LOS) in UCC patients and the number of left without being seen (LWBS) patients were calculated  
31 and compared under the three different levels of UCC crowding.  
32

33 **Results:** Four independent operational variables could affect the UCC overcrowding score including the total  
34 number of patients, the number of results pending patients, the number of patients in the waiting room, and the  
35 longest time a patient was stationed in the waiting room. In addition, UCC overcrowding was associated with  
36 longer average LOS (not overcrowded: 133±76min, overcrowded: 169±79min, and severely overcrowded:  
37 196±87min,  $p<0.001$ ) and an increased number of LWBS patients (not overcrowded: 0.28±0.69 patients,  
38 overcrowded: 0.64±.98, and severely overcrowded: 1.00±0.97).

39 **Conclusions:** The overcrowding estimation tool (SONET) derived in this study can be used to determine different  
40 levels of crowding in a high volume UCC setting. It also showed UCC overcrowding is associated with negative  
41 patient care outcomes.

42 **Key Words:** Urgent care center, Crowding, Tool, Patient care outcome

43 **Strengths and Limitations of this study:** Strengths: 1) the first prospective study on urgent care overcrowding, 2)  
44 the first study reported the link with the overcrowding and patient outcome in the urgent care setting, 3) derived a  
45 new overcrowding scoring system for urgent care crowding estimation which has not reported before. Limitations: 1)  
46 single center study requiring external validation; 2) special population selection could lead to selection bias.

## 47 Introduction

48 As the demand for real time access to care increases, Emergency Department (ED) overcrowding has become more  
49 and more common in recent years.<sup>1,2</sup> One of the solutions to ED overcrowding is to reduce the numbers of low  
50 acuity patients presenting for care.<sup>3,4</sup> It is reported that hospitals are adding their own or partnering with existing  
51 non-hospital based urgent care centers (UCCs) to offset ED overcrowding.<sup>5,6</sup> According to the report from the  
52 Urgent Care Association of America, the number of UCCs has increased over 12% within 3 years and it has  
53 provided care to over 3 million patient visits every week.<sup>7</sup> UCCs are now recognized as providing convenient, less  
54 expensive access to care as compared to that experienced at an average ED.

55 In primary care settings, the gap of available providers is expected to continue to grow. The primary care setting  
56 workload is expected to increase by 29% from 2005 to 2025. Meanwhile the number of primary care providers is  
57 expected to grow by only 2%-7% during the same timeframe.<sup>8,9</sup> Given the prediction that both ED and primary care  
58 settings will continue to be resource constrained, a proactive approach to anticipating UCC overcrowding will offer

59 a means to mitigate patient care risk. To the best of our knowledge, no UCC overcrowding estimation tool has been  
60 reported to date.

61 Accurately estimating UCC overcrowding will not only help reduce ED overcrowding but will also alert  
62 administrators to take action by mobilizing resources as an overcrowded condition becomes imminent thereby  
63 minimizing the risk of undesirable patient care outcomes.<sup>10,11</sup> The primary goal of this study is to derive a suitable  
64 tool we named SONET (Severely overcrowded – Overcrowded – Not overcrowded Estimation Tool) to evaluate  
65 overcrowding in a high volume UCC setting. A secondary goal is to determine the association between UCC  
66 overcrowding and negative patient care outcomes.

67

## 68 Materials and Methods

### 69 Study design and Patient population:

70 This was a prospective pilot study designed to derive an estimation tool to determine overcrowding status in a  
71 moderate to high volume UCC setting. This study was carried out at a publicly funded health system that has both  
72 ED and UCC at different locations within the main campus and with separate triage systems. The annual volume of  
73 the study UCC is approximately 62,000 visits. Considering no previous UCC overcrowding study reported and no  
74 historical data available for sample size estimation, the same study period used for Emergency Department  
75 overcrowding study was used in this study.<sup>12</sup> The John Peter Smith Health Network Institutional Review Board  
76 approved the study (IRB approval number: 110413.003ex).

77

78 All patients that registered initially at UCC were included in this study. Patients were triaged by dedicated nurses at  
79 the triage encounter point and individual patient acuity levels were then assigned by using the Emergency Severity  
80 Index (ESI). Patients with potentially higher levels of acuity (e.g. ESI 1 and 2) are routed to a physician immediately.  
81 Physician discretion is employed to determine if these patients need to transfer to ED for further emergent  
82 evaluation and treatment. Those patients at ESI levels 1 and 2 who were not sent to the ED remain in the urgent care  
83 workflow. Patients who had no overcrowding statuses estimated due to incomplete collection of operational  
84 variables at the time of registration were excluded in this study.

85

### 86 Study protocol

87 This study was carried out from Feb 24, 2014 through Mar 16, 2014. During these 21 days, all physicians, advanced  
88 practice providers (APP), charge nurses, flow coordinator nurses, and triage nurses were called separately every two  
89 hours by a dedicated UCC clerk and asked to report their perception of the current UCC crowding status. The UCC  
90 clerk was blinded to this study. The perceptions of UCC overcrowding were rated on a 0-100mm visual analogue  
91 scale (VAS). UCC overcrowding was considered to be true if the score on the VAS  $\geq 50$  and was considered  
92 severely overcrowded if the score on the VAS  $\geq 70$ . An average UCC overcrowding score was then calculated.  
93 Since no UCC overcrowding scale was reported before, our study overcrowding score was multiplied by a factor of  
94 2 in order to match an ED overcrowding scale that is widely used nationally.<sup>12</sup> A score  $\geq 100$  was considered  
95 overcrowded and  $\geq 140$  was considered severely overcrowded. Therefore, three different crowding statuses were  
96 considered: not-overcrowded, overcrowded, and severely overcrowded.

97 UCC opens at 0600 and closes around 2300 during weekdays. During the weekend, UCC opens at 0600 but closes at  
98 variable times depending on the volume of patients presenting during the course of the day. UCC triage ends at 2200.  
99 Patients who present after 2200 are redirected to ED for further evaluation and treatment. UCC closes after the last  
100 patient's disposition which is usually around 2300. The perception of UCC crowding status was queried 8 times

each day during the weekdays at 0700, 0900, 1100, 1300, 1500, 1700, 1900, and 2100 separately. During the weekend, queries occurred at 0700 and then every 2 hours until UCC closed. Patients who registered between 0600 and 0700 were considered under the not-overcrowded category.

At the same time provider perceptions of UCC crowding were asked by the UCC clerk, all variables were also recorded simultaneously by that clerk who did not participate in this study. The clinical or operational variables considered to potentially affect UCC crowding were collected after discussion with a group of those with operational expertise. A scoring tool to determine UCC crowding was then derived from the study that we named SONET (Severely-overcrowded Overcrowded Not-overcrowded Estimation Tool). Additionally, 1,000 sample randomized data sets were employed to validate the study internally by using the bootstrap methods.

Variables

The total number of UCC beds was used as a constant in this study. All the other clinical or operational variables such as the total number of patients at UCC, the number of patients in the waiting room, the number of attending physicians, APPs, and nurses on duty, the number of patients with different Emergency Severity Index (ESI) levels, and the longest wait time of those patients in the waiting room at the time of scoring were also collected (see Table 1). In order to potentially apply the SONET scoring system to different UCC settings, several indices were calculated as well. The total patient index was the total number of patients at UCC divided by the number of UCC beds. The waiting room patient index was the number of patients in the waiting room divided by the number of UCC beds. The results pending patient index was the total number of results pending patients (e.g. patients already seen by healthcare providers at UCC and then placed in the result pending area) divided by the number of active patients (e.g. active patients were the total number of UCC registered patients less the number of patients in the waiting room). The physician index was the total number of patients at UCC divided by the number of physicians on duty. The nurse index was the total number of patients at UCC divided by the number of nurses on duty. The APP index was the total number of patients at UCC divided by the number of APPs on duty.

Table 1. Clinical and operational variables and indices collected in the UCC overcrowding study

Variables		
The total number of patients at UCC	The number of patients already transferred to other facilities in the past two hours	The number of physicians on duty
Total number of patients in the waiting room	The number of patients with ESI 1 or 2 transferred to other facilities in the past two hours	The number of nurses on duty
The number of patients in the results pending area	The number of patients waiting to be transferred to other facilities	The number of APPs on duty
The number of patients with different assigned acuity levels (ESI 1, 2, 3, 4, 5)	The number of patients waiting to be discharged	The number of triage nurses on duty
The number of patients with different assigned acuity levels in the waiting room (ESI 3, 4, 5)	The longest wait time among patients in the waiting room expressed in hours	
Index		
Total patient index	Results pending patient index	Waiting room patient index
Nurse index	APP index	Physician index

Abbreviations: UCC urgent care center, ESI: emergency severity index, APP: advanced practice provider. The number of patients in the results pending area refers to the number of patients that had already been seen by a healthcare provider and were awaiting results of diagnostic testing. After initial provider interview and physical

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2  
3 130 exam these patients are relocated from the exam room to the results pending area. The total patient index is the total  
4 131 number of patients at UCC divided by the number of UCC beds. The results pending patient index is the total  
5 132 number of patients residing in the results pending status (e.g. patients already seen by healthcare providers at UCC  
6 133 and then transitioned to the results pending area) divided by the number of active patients (e.g. active patients were  
7 134 the total number of patients in UCC less those patients in the waiting room). The waiting room patient index was  
8 135 the number of patients in the waiting room divided by the number of UCC beds. The nurse index was the total  
9 136 number of patients at UCC divided by the number of nurses on duty. The APP index was the total number of  
10 137 patients at UCC divided by the number of APPs on duty. The physician index was the total number of patients at  
11 138 UCC divided by the number of physicians on duty.

139

#### 140 Outcome measurement

141 The SONET score was derived after the study was completed and retrospectively entered into the study data. All  
142 patients during the study period were assigned to have SONET scores at the time the patients were registered in the  
143 UCC and stratified into three different crowding categories. Patients who registered at UCC with incomplete data  
144 were excluded from the study as their individual SONET scores could not be calculated.

145 In order to know whether UCC overcrowding potentially affects UCC operational efficiency, LOS and the number  
146 of LWBS patients were used as markers for UCC efficiency measurements. UCC LOS refers to the interval of time  
147 starting with initial UCC patient registration and ending at the point when a patient is physically discharged from the  
148 UCC track board. For LWBS patients, the LOS was calculated as the interval of time starting with initial UCC  
149 registration and ending at the point that no response to a call for further service was documented. We performed  
150 three calls to every LWBS patient in a twenty minutes interval. If no response was received after the third call, the  
151 patient was considered LWBS and the time of the first call was recorded as the documented time of no response. All  
152 patients registered for UCC services during the study period were included in the data analysis. Patient care  
153 outcomes were compared among these three groups (not-overcrowded, overcrowded, and severely overcrowded  
154 groups).

155

#### 156 Data analysis and Statistics

157 A linear regression model was applied and the independent operational variables that could affect UCC  
158 overcrowding status scores were determined. Correlation coefficient ( $r$ ) was analyzed on each operational variable  
159 with its scatter plot drawn. Variables that had strong correlation ( $r > 0.6$ ) with UCC crowding were chosen for linear  
160 regression analysis. Variance inflation factor (VIF) quantifies the severity of multi-collinearity in the regression  
161 model analysis thereby providing an index to estimate whether the regression coefficient is increased due to  
162 collinearity. Operational variables with high VIF ( $> 10$ ) were considered as having collinearity and were therefore  
163 excluded from regression analysis.<sup>13,14</sup> A formula was then generated based on the regression coefficient of each  
164 independent operational variable and an UCC crowding score was calculated. A bootstrap technique that  
165 randomized 1,000 samples was used to internally validate the study score accuracy.

166 Considering the operational significance of determining UCC overcrowding status, the SONET score was divided  
167 into three categories: not overcrowded (score  $< 100$ ), overcrowded (score between 100 and 140, including 100 but  
168 not including 140), and severely overcrowded (score  $\geq 140$ ). Patients were automatically assigned to three groups based  
169 on ED overcrowding scores at the time when a specific patient registered for services in the UCC. To compare the  
170 differences between LWBS, and LOS at UCC relative to the different UCC overcrowding status groups, analysis of  
171 variance (ANOVA) with Bonferroni correction was used to analyze differences between groups.

172 All statistical analysis was performed using STATA 12 (College Station, TX) and a  $p < 0.05$  was considered a  
173 statistically significant difference.

174  
175 **Results**

176 Derivation of SONET scoring system

177 The prospective pilot study was performed from 0600 on Feb 24, 2014 until 1900 on Mar. 16, 2014 which included  
178 15 weekdays and 6 weekend days. The UCC closes operations at different times during the weekends resulting in 36  
179 data sets collected at different time points. Therefore, there were a total of 134 data sets collected resulting in a data  
180 completion rate of 85.9% (134/156). Among these 134 time points, the UCC was determined by healthcare provider  
181 perceptions to be below the not-overcrowded threshold 57.46% (77/134) of the time. The UCC was determined to be  
182 below the overcrowded threshold 26.12% (35/134) of the time and below the severely overcrowded threshold 16.42%  
183 (22/134) of the time.

184 Results of linear regression showed only 4 variables that can be considered independent risk factors affecting the  
185 UCC crowding status. These are total number of patients, number of results pending patients, number of patients in  
186 the waiting room, and longest wait time of patients in the waiting room. Other variables reached either no statistical  
187 significance, had no correlation with overcrowding, or had significant colinearity with a VIF (variance inflation  
188 factor) greater than 10. In order to suitably apply the tool with respect to different UCC settings, total patient index  
189 and waiting room patient index were used. Therefore a UCC crowding scoring formula (SONET) was derived and is  
190 defined as:

191  $SONET\ Score = 24.5 \times total\ patient\ index + 58.1 \times waiting\ room\ patient\ index + 2.7 \times number\ of\ result\ pending$   
192  $patients + 12.2 \times the\ longest\ time\ in\ hours\ of\ patient\ in\ the\ waiting\ room + 32.4.$  (in short form:  $SONET\ Score =$   
193  $24.5T+58.1WI+2.7R+12.2L+32.4$  (TWIRL) where T indicates the total patients index, WI indicates the waiting  
194 room patient index, R indicates the number of results pending patients in UCC, and L indicates the longest time in  
195 hours of patients in the waiting room).  $SONET\ score \geq 100$  is considered UCC overcrowded and  $\geq 140$  is considered  
196 severely overcrowded.

197 Using the average perceptions of UCC crowding status among different healthcare providers as a “gold standard”  
198 demonstrated strong inter-rater reliability between the SONET scores and provider perceptions when compared  
199 within the three different crowding statuses (not overcrowded, overcrowded, and severely overcrowded,  $\kappa=0.6446$ ).  
200 Internal validation using bootstrap methods showed similar results (data not shown).

201

202 Outcome measurement

203 A total of 3,565 patients were registered to receive services in the UCC during the study period. Excluding patients  
204 who had no SONET scores calculated due to incomplete collection of operational variables at the time of  
205 registration, 3,139 patients were enrolled in data analysis. The general information of these patients is shown in  
206 Table 2.

207 Table 2. General Information of Patients in the study

Age (year±SD)	41.97±15.57 (95%CI 41.43-42.52)
Gender (male, %)	46.70%
Level of Acuity (% , number)	
ESI1	0.16% (5)
ESI2	5.61% (176)
ESI3	24.94% (783)
ESI4	59.64% (1,872)
ESI5	8.00% (251)

unknown	1.66% (52)
Disposition (% , number)	
Discharged	89.58% (2812)
Admitted	4.17% (131)
LWBS	1.94% (61)
Average time intervals (min±SD)	
from patient arrival to triage	7.9±7.0 (95% CI 7.6-8.1)
from patient arrival to placement in an exam room	42.6±41.4 (95% CI 41.2-44.1)
from patient arrival to patient initial encounter with a healthcare provider	75.9±56.6 (95% CI 74.0-77.9)
from patient arrival to disposition (discharge vs. admit) rendered	132.5±82.7 (95% CI 129.6-135.4)
from patient arrival to patient departure from UCC	151.6±89.5 (95%CI 148.5-154.7)

In order to determine whether the UCC overcrowding status could affect UCC operational efficiency and safety, LOS and LWBS were investigated. Patients registered at UCC triage during the study period were assigned to three different UCC crowding statuses determined by SONET scores (N: not overcrowded; O: overcrowded; and S: severely overcrowded).

The average LOS at UCC under each crowding status determined by SONET reached statistically significant differences between groups. Similar results were found when patients were further subdivided into the different ESI level groups (Table 3). The more severe the crowding score in the UCC, the longer the average LOS of all patients, especially those triaged to ESI levels 3, 4, and 5. When analyzing only discharged patients, similar results were found with statistically significant differences among groups (Appendix Table). To more accurately determine the effects of UCC crowding status on delayed patient care LOS was divided into several segments. The segments were time spent at triage, wait time for an available exam room, wait time to arrival of a healthcare provider, and wait time to disposition (Table 4). The results of our study showed that the most significant delay in care occurred during the period while patients awaited an available exam room. No significant difference was noted after patients were initially seen by the healthcare providers.

Appendix Table. The average LOS of discharged patients who registered at UCC under the different crowding statuses as determined by the SONET tool.

	Average LOS of Patients at UCC (min±SD, number of patients)					
	All patients	ESI-1	ESI-2	ESI-3	ESI-4	ESI-5
Not Overcrowded	133±76 (1445)	0	76±72 (35)	140±88 (335)	138±73 (952)	95±46 (120)
Overcrowded	169±79 (858) <i>*p&lt;0.001</i>	0	78±61 (37) <i>*p=1.000</i>	172±93 (218) <i>*p&lt;0.001</i>	179±72 (522) <i>*p&lt;0.001</i>	138±53 (80) <i>*p&lt;0.001</i>
Severely Overcrowded	196±87 (509) <i>**p&lt;0.001</i>	0	69±55 (27) <i>**p=1.000</i>	188±99 (130) <i>**p=0.327</i>	211±75 (315) <i>**p&lt;0.001</i>	189±83 (37) <i>**p&lt;0.001</i>

Abbreviation: LOS: length of stay (time interval from initial patient registration to departure from UCC); UCC: urgent care center; SD: standard deviation; ESI: Emergency Severity Index. \*: comparison between not overcrowded and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

231 Table 3. The average LOS of patients who registered at UCC as a function of relative acuity status and SONET  
 232 score

	Average LOS of Patients at UCC (min±SD, number of patients)					
	All patients	ESI-1	ESI-2	ESI-3	ESI-4	ESI-5
Not Overcrowded	130±80 (1581)	57±67 (2)	59±56 (69)	136±95 (385)	139±73 (981)	93±47 (125)
Overcrowded	165±88 (957) *p<0.001	58±55 (3) *p=0.973	71±62 (58) *p=0.733	170±102 (242) *p<0.001	181±79 (549) *p<0.001	139±53 (87) *p<0.001
Severely Overcrowded	186±97 (601) **p<0.001		57±48 (49) **p=0.699	192±114 (156) **p=0.112	208±75 (342) **p<0.001	187±83 (39) **p<0.001

233 Abbreviation: LOS: length of stay (time interval from initial patient registration to departure from UCC); UCC:  
 234 urgent care center; SD: standard deviation; ESI: Emergency Severity index. \*: comparison between not overcrowded  
 235 and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

236 Table 4. Patient encounter average time intervals as a function of relative crowding status determined by the SONET  
 237 score

	Average time spend of Patients at different phases (min±SD)					
	Arrival to Triage	Triage encounter	Triage to patient placed in an exam room	Patient placed in an exam room to patient seen by a healthcare provider	Patient seen by a healthcare provider to disposition decision	Disposition decision to patient departure from UCC
Not overcrowded	6.8±6.4	2.3±2.2	17.4±25.7	30.3±30.7	54.8±57.5	19.6±17.4
Overcrowded	7.9±6.8 *p<0.001	2.5±2.2 *p=0.097	38.5±35.6 *p<0.001	39.4±33.8 *p<0.001	56.1±63.0 *p=1.000	21.0±20.8 *p=0.267
Severely Overcrowded	10.6±8.1 **p<0.001	2.8±2.5 **p=0.210	60.9±52.7 **p<0.001	31.3±30.0 **p<0.001	57.6±69.2 **p=1.000	21.3±21.0 **p=1.000

238 Abbreviation: UCC: urgent care center; SD: standard deviation. \*: comparison between not overcrowded and  
 239 overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

240  
 241 LWBS data was collected every two hours. The numbers of LWBS patients was 0.28±0.69 every two hours if UCC  
 242 was under a not-overcrowded status, 0.64±0.98 when at an overcrowded status, and 1.00±0.97 when at a severely  
 243 overcrowded status. The results show the numbers of LWBS patients were associated with the severity of UCC  
 244 crowding as determined by the SONET scores however not sufficiently powered to reach statistical significance  
 245 (p>0.05).

246  
 247 **Discussion**

248 Providing urgent care services to meet the needs of the evolving healthcare consumer is gaining considerable  
 249 interest by the industry. The number of UCC patients has increased substantially every year resulting in the potential  
 250 for UCC saturation and resultant overcrowding. To date no UCC overcrowding estimation tool was available.<sup>15,16</sup> In  
 251 order to maintain a high standard of clinical and operational performance in the urgent care setting, assessment of  
 252 UCC overcrowding is critical to effective management. Much research has been done on ED overcrowding, but



### 303 Limitations

304 This study was performed in a single urban UCC affiliated with a publicly funded hospital system which could  
305 inevitably have population selection bias and limit its use in a more general setting. Considering the study was  
306 performed in a relatively high volume UCC setting, this crowding estimation tool might only accurately reflect  
307 conditions typically encountered in a similar setting. In addition, the study facility has an emergency psychiatric unit  
308 which directly and indirectly accepts patients with urgent and emergent psychiatric conditions. As such very few  
309 patients with psychiatric problems present to UCC resulting in a potential bias in terms of population selection.  
310 Therefore, results of this study need to be validated in a multicenter study involving different UCC settings and  
311 populations. Operational variables chosen in this study were based upon previous ED overcrowding studies and  
312 expertise recommendations, As such other variables that potentially affect UCC crowding might have been missed.  
313 During our study period, the process of triaging a low acuity (ESI levels 4 and 5) ED patient to UCC when the ED is  
314 determined to be severely overcrowded was not yet initiated. Therefore, the number of patients transferred from ED  
315 to UCC was not considered a risk factor impacting UCC crowding. Furthermore, consideration of average LOS and  
316 numbers of LWBS patients as the only patient care outcome measurements may not be enough to determine the  
317 most accurate association to UCC crowding. Other patient care outcome variables such as 72h UCC/ED returns,  
318 patient satisfaction, and nosocomial accidents might need to be included.

319

### 320 Conclusion

321 An overcrowding estimation tool (SONET) used to determine relative crowding status in a high volume UCC setting  
322 was derived in this study. The study also showed that UCC overcrowding is associated with negative patient care  
323 outcomes.

324

325 **Competing Interests:** N/A

326

327 **Author contributions:** HW and RDR conceived the study and developed the design in consultation with all of the  
328 authors. CDC<sup>1</sup>, VAG, and CDC<sup>2</sup> assembled the data set and collected the data. HW, RDR, EKG, CDS, RDJ, and  
329 NRZ conducted the statistical analyses and drafted the article, and all authors read and approved the final manuscript.  
330 HW takes responsibility for the paper as a whole. (1: CDC: Chad D. Cowden; 2: CDC: Christopher D. Cook)

331

332 **Acknowledgement:** We would like to thank all the UCC attending physicians, APPs, nursing staff, and unit clerks  
333 participating in this study.

334

### 335 Table legend:

336 Table 1 shows the clinical and operational variables and index collected in the UCC overcrowding study. There  
337 were total 20 individual operational variables and 5 indexes collected based on the previous ED overcrowding study  
338 and expertise's opinions.

339 Table 2 shows the general information of patients in this study

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3 340 Table 3 shows the average LOS of patients who registered at UCC under the different crowding statuses determined  
4 341 by the SONET.  
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6 342 Table 4 shows the average time spend at different stages in patients who registered at UCC under the different  
7 343 crowding statuses determined by the SONET  
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9 344 Appendix table shows the average LOS of discharged patients who registered at UCC under the different crowding  
10 345 statuses determined by the SONET  
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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	<p>(a) Indicate the study’s design with a commonly used term in the title or the abstract</p> <p>(b) Provide in the abstract an informative and balanced summary of what was done and what was found</p> <p>Explanation: a) <b>Yes</b>. This is a prospective study and was reported in the abstract section. b) <b>Yes</b>. In abstract, clearly addressed what was done and in result section, the findings were also reported.</p>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b>Yes</b> , we address the scientific background and the rationale for this study.
Objectives	3	State specific objectives, including any prespecified hypotheses <b>Yes</b> , in the end of the introduction section, we reported a specific urgent care center overcrowding estimation tool will be derived and study primary and secondary goals (hypotheses)
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b>Yes</b> , study design was reported in Line 70.
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b>Yes</b> , location: Line 71-72, periods of recruitment: Line 87, exposure, follow-up: Line 78-84, this study did not require follow-up. Data collection: Line 111-154.
Participants	6	<i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b>Yes</b> , Line 78-84, this study did not require follow up.
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b>Yes</b> , see section Variables: Line111-138 and table 1.
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 <b>Yes</b> , see section Variables: Line111-138 and table 1.
Bias	9	Describe any efforts to address potential sources of bias <b>Yes</b> , single center study with population selection bias will be inevitably occurred and this is addressed in our limitation section.
Study size	10	Explain how the study size was arrived at <b>Yes</b> , line 73-75.
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b>Yes</b> , three groups were divided in this study (N: not overcrowding; O: overcrowding; and S: severely overcrowding groups) and outcome measurements were compared with these three groups. See Line 145-154. How quantitative variables were handled

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		<i>in the analyses were also addressed in the statistics section</i> See Line 166-171.
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding
		(b) Describe any methods used to examine subgroups and interactions
		(c) Explain how missing data were addressed
		(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed
		<i>Yes</i> , a): statistical methods addressed in detail in Line 155-172. b): see Line 166-170.
		c) see line 78-84. d) this study did not require any follow-up.
		(e) Describe any sensitivity analyses
		N/A: no sensitivity analyses addressed in this study since there is no standard or previous similar study reported. However, consider the perceptions of overcrowding of healthcare providers as a “gold standard”, inter-rater reliability between the SONET scores and provider perceptions was measured. Line 197-200

Continued on next page

For peer review only

**Results**

Participants	13*	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Yes, see line 202-205. Table 2
		Give reasons for non-participation at each stage Yes, see line 202-203
		Consider use of a flow diagram No, since this is very easy to address in the manuscript, no flow diagram drawn.
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders Yes, see Table 2.
		(b) Indicate number of participants with missing data for each variable of interest Yes, see line 179-180, and 202-205.
		(c) Cohort study—Summarise follow-up time (eg, average and total amount) No, this study did not require follow-up.
Outcome data	15*	Cohort study—Report numbers of outcome events or summary measures over time Case-control study—Report numbers in each exposure category, or summary measures of exposure Cross-sectional study—Report numbers of outcome events or summary measures Yes, see result section: outcome measurements Line 201-244.
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included Yes, see Line 184-196. Results showed only 4 variables can be independent variables while others are the confounding factors.
		(b) Report category boundaries when continuous variables were categorized Yes, continuous variables are converted to categorical variables based on the results of previous study. See line 90-96.
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses Yes, see Table 4 and Appendix Table.
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives Yes, see Line 247-256.
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 Yes, see limitation section Line 302-317.
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence Yes, see discussion Line 257-300.
Generalisability	21	Discuss the generalisability (external validity) of the study results Yes, internal validation performed and no external validation reported in this study and also

addressed in the limitation. see Line 200, 310-311.

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**Other information**

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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  
N/A

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

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# BMJ Open

## Use of the SONET Score to Evaluate Urgent Care Center Overcrowding

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1 Title Page:

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3 Title: Use of the SONET Score to Evaluate Urgent Care Center Overcrowding

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13

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15

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59 a means to mitigate patient care risk. To the best of our knowledge, no UCC overcrowding estimation tool has been  
60 reported to date.

61 Accurately estimating UCC overcrowding will not only help reduce ED overcrowding but will also alert  
62 administrators to take action by mobilizing resources as an overcrowded condition becomes imminent thereby  
63 minimizing the risk of undesirable patient care outcomes.<sup>10:11</sup> The primary goal of this study is to derive a suitable  
64 tool we named SONET (Severely overcrowded – Overcrowded – Not overcrowded Estimation Tool) to evaluate  
65 overcrowding in a high volume UCC setting. A secondary goal is to determine the association between UCC  
66 overcrowding and negative patient care outcomes.

67  
68 Materials and Methods

69 Study design and Patient population:

70 This was a prospective pilot study designed to derive an estimation tool to determine overcrowding status in a  
71 moderate to high volume UCC setting. This study was carried out at a publicly funded health system that has both  
72 ED and UCC at different locations within the main campus and with separate triage systems. The annual volume of  
73 the study UCC is approximately 62,000 visits. Considering no previous UCC overcrowding study reported and no  
74 historical data available for sample size estimation, the same study period used for Emergency Department  
75 overcrowding study was used in this study.<sup>12</sup> The John Peter Smith Health Network Institutional Review Board  
76 approved the study (IRB approval number: 110413.003ex).

77  
78 All patients that registered initially at UCC were included in this study. Patients were triaged by dedicated nurses at  
79 the triage encounter point and individual patient acuity levels were then assigned by using the Emergency Severity  
80 Index (ESI). ESI is a standardized ED/UCC triage system confirmed to be a reliable and valid triage system in US to  
81 determine the different acuity levels upon each patients’ entry into the service.<sup>13</sup> Patients with potentially higher  
82 levels of acuity (e.g. ESI 1 and 2) are routed to a physician immediately. Physician discretion is employed to  
83 determine if these patients need to transfer to ED for further emergent evaluation and treatment. Those patients at  
84 ESI levels 1 and 2 who were not sent to the ED remain in the urgent care workflow. Patients who had no  
85 overcrowding statuses estimated due to incomplete collection of operational variables at the time of registration  
86 were excluded in this study.

87  
88 Study protocol

89 This study was carried out from Feb 24, 2014 through Mar 16, 2014. During these 21 days, all physicians, advanced  
90 practice providers (APP), charge nurses, flow coordinator nurses, and triage nurses were called separately every two  
91 hours by a dedicated UCC clerk and asked to report their perception of the current UCC crowding status. The UCC  
92 clerk was blinded to this study. The perceptions of UCC overcrowding were rated on a 0-100mm visual analogue  
93 scale (VAS). UCC overcrowding was considered to be true if the score on the VAS  $\geq 50$  and was considered  
94 severely overcrowded if the score on the VAS  $\geq 70$ . An average UCC overcrowding score was then calculated.  
95 Since no UCC overcrowding scale was reported before, our study overcrowding score was multiplied by a factor of  
96 2 in order to match an ED overcrowding scale that is widely used nationally.<sup>12</sup> A score  $\geq 100$  was considered  
97 overcrowded and  $\geq 140$  was considered severely overcrowded. Therefore, three different crowding statuses were  
98 considered: not-overcrowded, overcrowded, and severely overcrowded.

99 UCC opens at 0600 and closes around 2300 during weekdays. During the weekend, UCC opens at 0600 but closes at  
100 variable times depending on the volume of patients presenting during the course of the day. UCC triage ends at 2200.

101 Patients who present after 2200 are redirected to ED for further evaluation and treatment. UCC closes after the last  
 102 patient's disposition which is usually around 2300. The perception of UCC crowding status was queried 8 times  
 103 each day during the weekdays at 0700, 0900, 1100, 1300, 1500, 1700, 1900, and 2100 separately. During the  
 104 weekend, queries occurred at 0700 and then every 2 hours until UCC closed. Patients who registered between 0600  
 105 and 0700 were considered under the not-overcrowded category.

106 At the same time provider perceptions of UCC crowding were asked by the UCC clerk, all variables were also  
 107 recorded simultaneously by that clerk who did not participate in this study. The clinical or operational variables  
 108 considered to potentially affect UCC crowding were collected after discussion with a group of those with  
 109 operational expertise. A scoring tool to determine UCC crowding was then derived from the study that we named  
 110 SONET (Severely-overcrowded Overcrowded Not-overcrowded Estimation Tool). Additionally, 1,000 sample  
 111 randomized data sets were employed to validate the study internally by using the bootstrap methods.

112

113 Variables

114 The total number of UCC beds was used as a constant in this study. All the other clinical or operational variables  
 115 such as the total number of patients at UCC, the number of patients in the waiting room, the number of attending  
 116 physicians, APPs, and nurses on duty, the number of patients with different Emergency Severity Index (ESI) levels,  
 117 and the longest wait time of those patients in the waiting room at the time of scoring were also collected (see Table  
 118 1). In order to potentially apply the SONET scoring system to different UCC settings, several indices were  
 119 calculated as well. The total patient index was the total number of patients at UCC divided by the number of UCC  
 120 beds. The waiting room patient index was the number of patients in the waiting room divided by the number of UCC  
 121 beds. The results pending patient index was the total number of results pending patients (e.g. patients already seen  
 122 by healthcare providers at UCC and then placed in the result pending area) divided by the number of active patients  
 123 (e.g. active patients were the total number of UCC registered patients less the number of patients in the waiting  
 124 room). The physician index was the total number of patients at UCC divided by the number of physicians on duty.  
 125 The nurse index was the total number of patients at UCC divided by the number of nurses on duty. The APP index  
 126 was the total number of patients at UCC divided by the number of APPs on duty.

127

128 Table 1. Clinical and operational variables and indices collected in the UCC overcrowding study

Variables		
The total number of patients at UCC	The number of patients already transferred to other facilities in the past two hours	The number of physicians on duty
Total number of patients in the waiting room	The number of patients with ESI 1 or 2 transferred to other facilities in the past two hours	The number of nurses on duty
The number of patients in the results pending area	The number of patients waiting to be transferred to other facilities	The number of APPs on duty
The number of patients with different assigned acuity levels (ESI 1, 2, 3, 4, 5)	The number of patients waiting to be discharged	The number of triage nurses on duty
The number of patients with different assigned acuity levels in the waiting room (ESI 3, 4, 5)	The longest wait time among patients in the waiting room expressed in hours	
Index		
Total patient index	Results pending patient index	Waiting room patient index
Nurse index	APP index	Physician index

129 Abbreviations: UCC urgent care center, ESI: emergency severity index, APP: advanced practice provider. The  
 130 number of patients in the results pending area refers to the number of patients that had already been seen by a  
 131 healthcare provider and were awaiting results of diagnostic testing. After initial provider interview and physical  
 132 exam these patients are relocated from the exam room to the results pending area. The total patient index is the total  
 133 number of patients at UCC divided by the number of UCC beds. The results pending patient index is the total  
 134 number of patients residing in the results pending status (e.g. patients already seen by healthcare providers at UCC  
 135 and then transitioned to the results pending area) divided by the number of active patients (e.g. active patients were  
 136 the total number of patients in UCC less those patients in the waiting room). The waiting room patient index was  
 137 the number of patients in the waiting room divided by the number of UCC beds. The nurse index was the total  
 138 number of patients at UCC divided by the number of nurses on duty. The APP index was the total number of  
 139 patients at UCC divided by the number of APPs on duty. The physician index was the total number of patients at  
 140 UCC divided by the number of physicians on duty.

141

142 Outcome measurement

143 The SONET score was derived after the study was completed and retrospectively entered into the study data. All  
 144 patients during the study period were assigned to have SONET scores at the time the patients were registered in the  
 145 UCC and stratified into three different crowding categories. Patients who registered at UCC with incomplete data  
 146 were excluded from the study as their individual SONET scores could not be calculated.

147 In order to know whether UCC overcrowding potentially affects UCC operational efficiency, LOS and the number  
 148 of LWBS patients were used as markers for UCC efficiency measurements. UCC LOS refers to the interval of time  
 149 starting with initial UCC patient registration and ending at the point when a patient is physically discharged from the  
 150 UCC track board. For LWBS patients, the LOS was calculated as the interval of time starting with initial UCC  
 151 registration and ending at the point that no response to a call for further service was documented. We performed  
 152 three calls to every LWBS patient in a twenty minutes interval. If no response was received after the third call, the  
 153 patient was considered LWBS and the time of the first call was recorded as the documented time of no response. All  
 154 patients registered for UCC services during the study period were included in the data analysis. Patient care  
 155 outcomes were compared among these three groups (not-overcrowded, overcrowded, and severely overcrowded  
 156 groups).

157

158 Data analysis and Statistics

159 A linear regression model was applied and the independent operational variables that could affect UCC  
 160 overcrowding status scores were determined. Correlation coefficient ( $r$ ) was analyzed on each operational variable  
 161 with its scatter plot drawn. Variables that had strong correlation ( $r > 0.6$ ) with UCC crowding were chosen for linear  
 162 regression analysis. Variance inflation factor (VIF) quantifies the severity of multi-collinearity in the regression  
 163 model analysis thereby providing an index to estimate whether the regression coefficient is increased due to  
 164 collinearity. Operational variables with high VIF ( $> 10$ ) were considered as having collinearity and were therefore  
 165 excluded from regression analysis.<sup>14,15</sup> A formula was then generated based on the regression coefficient of each  
 166 independent operational variable and an UCC crowding score was calculated. A bootstrap technique that  
 167 randomized 1,000 samples was used to internally validate the study score accuracy.

168 Considering the operational significance of determining UCC overcrowding status, the SONET score was divided  
 169 into three categories: not overcrowded (score  $< 100$ ), overcrowded (score between 100 and 140, including 100 but not  
 170 including 140), and severely overcrowded (score  $\geq 140$ ). Patients were automatically assigned to three groups based  
 171 on ED overcrowding scores at the time when a specific patient registered for services in the UCC. To compare the  
 172 differences between LWBS, and LOS at UCC relative to the different UCC overcrowding status groups, analysis of  
 173 variance (ANOVA) with Bonferroni correction was used to analyze differences between groups.

174 All statistical analysis was performed using STATA 12 (College Station, TX) and a  $p < 0.05$  was considered a  
 175 statistically significant difference.

176

177 **Results**

178 Derivation of SONET scoring system

179 The prospective pilot study was performed from 0600 on Feb 24, 2014 until 1900 on Mar. 16, 2014 which included  
 180 15 weekdays and 6 weekend days. The UCC closes operations at different times during the weekends resulting in 36  
 181 data sets collected at different time points. Therefore, there were a total of 134 data sets collected resulting in a data  
 182 completion rate of 85.9% (134/156). Among these 134 time points, the UCC was determined by healthcare provider  
 183 perceptions to be below the not-overcrowded threshold 57.46% (77/134) of the time. The UCC was determined to be  
 184 below the overcrowded threshold 26.12% (35/134) of the time and below the severely overcrowded threshold 16.42%  
 185 (22/134) of the time.

186 Results of linear regression showed only 4 variables that can be considered independent risk factors affecting the  
 187 UCC crowding status. These are total number of patients, number of results pending patients, number of patients in  
 188 the waiting room, and longest wait time of patients in the waiting room. Other variables reached either no statistical  
 189 significance, had no correlation with overcrowding, or had significant colinearity with a VIF (variance inflation  
 190 factor) greater than 10. In order to suitably apply the tool with respect to different UCC settings, total patient index  
 191 and waiting room patient index were used. Therefore a UCC crowding scoring formula (SONET) was derived and is  
 192 defined as:

193 SONET Score =  $24.5 \times \text{total patient index} + 58.1 \times \text{waiting room patient index} + 2.7 \times \text{number of result pending}$   
 194  $\text{patients} + 12.2 \times \text{the longest time in hours of patient in the waiting room} + 32.4$ . (in short form: SONET Score =  
 195  $24.5T+58.1WI+2.7R+12.2L+32.4$  (TWIRL) where T indicates the total patients index, WI indicates the waiting  
 196 room patient index, R indicates the number of results pending patients in UCC, and L indicates the longest time in  
 197 hours of patients in the waiting room). SONET score  $\geq 100$  is considered UCC overcrowded and  $\geq 140$  is considered  
 198 severely overcrowded.

199 Using the average perceptions of UCC crowding status among different healthcare providers as a “gold standard”  
 200 demonstrated strong inter-rater reliability between the SONET scores and provider perceptions when compared  
 201 within the three different crowding statuses (not overcrowded, overcrowded, and severely overcrowded,  $\kappa=0.6446$ ).  
 202 Internal validation using bootstrap methods showed similar results (data not shown).

203

204 Outcome measurement

205 A total of 3,565 patients were registered to receive services in the UCC during the study period. Excluding patients  
 206 who had no SONET scores calculated due to incomplete collection of operational variables at the time of  
 207 registration, 3,139 patients were enrolled in data analysis. The general information of these patients is shown in  
 208 Table 2.

209 Table 2. General Information of Patients in the study

Age (year±SD)	41.97±15.57 (95%CI 41.43-42.52)
Gender (male, %)	46.70%
Level of Acuity (% , number)	
ESI1	0.16% (5)
ESI2	5.61% (176)

ESI3	24.94% (783)
ESI4	59.64% (1,872)
ESI5	8.00% (251)
unknown	1.66% (52)
Disposition (%, number)	
Discharged	89.58% (2812)
Admitted	4.17% (131)
LWBS	1.94% (61)
Average time intervals (min±SD)	
from patient arrival to triage	7.9±7.0 (95% CI 7.6-8.1)
from patient arrival to placement in an exam room	42.6±41.4 (95% CI 41.2-44.1)
from patient arrival to patient initial encounter with a healthcare provider	75.9±56.6 (95% CI 74.0-77.9)
from patient arrival to disposition (discharge vs. admit) rendered	132.5±82.7 (95% CI 129.6-135.4)
from patient arrival to patient departure from UCC	151.6±89.5 (95% CI 148.5-154.7)

210  
211  
212 In order to determine whether the UCC overcrowding status could affect UCC operational efficiency and safety,  
213 LOS and LWBS were investigated. Patients registered at UCC triage during the study period were assigned to three  
214 different UCC crowding statuses determined by SONET scores (N: not overcrowded; O: overcrowded; and S:  
215 severely overcrowded).

216 The average LOS at UCC under each crowding status determined by SONET reached statistically significant  
217 differences between groups. Similar results were found when patients were further subdivided into the different ESI  
218 level groups (Table 3). The more severe the crowding score in the UCC, the longer the average LOS of all patients,  
219 especially those triaged to ESI levels 3, 4, and 5. When analyzing only discharged patients, similar results were  
220 found with statistically significant differences among groups (Appendix Table). To more accurately determine the  
221 effects of UCC crowding status on delayed patient care LOS was divided into several segments. The segments were  
222 time spent at triage, wait time for an available exam room, wait time to arrival of a healthcare provider, and wait  
223 time to disposition (Table 4). The results of our study showed that the most significant delay in care occurred during  
224 the period while patients awaited an available exam room. No significant difference was noted after patients were  
225 initially seen by the healthcare providers.

226  
227 Appendix Table. The average LOS of discharged patients who registered at UCC under the different crowding  
228 statuses as determined by the SONET tool.

Average LOS of Patients at UCC (min±SD, number of patients)						
	All patients	ESI-1	ESI-2	ESI-3	ESI-4	ESI-5
Not Overcrowded	133±76 (1445)	0	76±72 (35)	140±88 (335)	138±73 (952)	95±46 (120)
Overcrowded	169±79 (858) <i>*p</i> <0.001	0	78±61 (37) <i>*p</i> =1.000	172±93 (218) <i>*p</i> <0.001	179±72 (522) <i>*p</i> <0.001	138±53 (80) <i>*p</i> <0.001
Severely Overcrowded	196±87 (509) <i>**p</i> <0.001	0	69±55 (27) <i>**p</i> =1.000	188±99 (130) <i>**p</i> =0.327	211±75 (315) <i>**p</i> <0.001	189±83 (37) <i>**p</i> <0.001

229 Abbreviation: LOS: length of stay (time interval from initial patient registration to departure from UCC); UCC:  
230 urgent care center; SD: standard deviation; ESI: Emergency Severity Index. \*: comparison between not  
231 overcrowded and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

Table 3. The average LOS of patients who registered at UCC as a function of relative acuity status and SONET score

	Average LOS of Patients at UCC (min±SD, number of patients)					
	All patients	ESI-1	ESI-2	ESI-3	ESI-4	ESI-5
Not Overcrowded	130±80 (1581)	57±67 (2)	59±56 (69)	136±95 (385)	139±73 (981)	93±47 (125)
Overcrowded	165±88 (957) *p<0.001	58±55 (3) *p=0.973	71±62 (58) *p=0.733	170±102 (242) *p<0.001	181±79 (549) *p<0.001	139±53 (87) *p<0.001
Severely Overcrowded	186±97 (601) **p<0.001		57±48 (49) **p=0.699	192±114 (156) **p=0.112	208±75 (342) **p<0.001	187±83 (39) **p<0.001

Abbreviation: LOS: length of stay (time interval from initial patient registration to departure from UCC); UCC: urgent care center; SD: standard deviation; ESI: Emergency Severity index. \*: comparison between not overcrowded and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

Table 4. Patient encounter average time intervals as a function of relative crowding status determined by the SONET score

	Average time spend of Patients at different phases (min±SD)					
	Arrival to Triage	Triage encounter	Triage to patient placed in an exam room	Patient placed in an exam room to patient seen by a healthcare provider	Patient seen by a healthcare provider to disposition decision	Disposition decision to patient departure from UCC
Not overcrowded	6.8±6.4	2.3±2.2	17.4±25.7	30.3±30.7	54.8±57.5	19.6±17.4
Overcrowded	7.9±6.8 *p<0.001	2.5±2.2 *p=0.097	38.5±35.6 *p<0.001	39.4±33.8 *p<0.001	56.1±63.0 *p=1.000	21.0±20.8 *p=0.267
Severely Overcrowded	10.6±8.1 **p<0.001	2.8±2.5 **p=0.210	60.9±52.7 **p<0.001	31.3±30.0 **p<0.001	57.6±69.2 **p=1.000	21.3±21.0 **p=1.000

Abbreviation: UCC: urgent care center; SD: standard deviation. \*: comparison between not overcrowded and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

242

LWBS data was collected every two hours. The numbers of LWBS patients was 0.28±0.69 every two hours if UCC was under a not-overcrowded status, 0.64±0.98 when at an overcrowded status, and 1.00±0.97 when at a severely overcrowded status. The results show the numbers of LWBS patients were associated with the severity of UCC crowding as determined by the SONET scores however not sufficiently powered to reach statistical significance ( $p>0.05$ ).

248

## 249 Discussion

250 Providing urgent care services to meet the needs of the evolving healthcare consumer is gaining considerable interest by the industry. The number of UCC patients has increased substantially every year resulting in the potential for UCC saturation and resultant overcrowding. To date no UCC overcrowding estimation tool was available.<sup>16,17</sup> In order to maintain a high standard of clinical and operational performance in the urgent care setting, assessment of UCC overcrowding is critical to effective management. Much research has been done on ED overcrowding, but

255 minimal attention has been paid to overcrowding as it relates to UCC workflow.<sup>18-20</sup> Our institution operates both an  
256 ED and UCC at different locations with different triage system providing us an opportunity to investigate  
257 overcrowding at each discreet location. In this study, a UCC overcrowding estimation tool (SONET) was derived  
258 and also showed the prolonged average LOS and increased number of LWBS patients linked closely with the  
259 severity levels of UCC overcrowding.

260 Since no UCC overcrowding tool has been reported, the operational variables chosen for deriving our UCC  
261 overcrowding tool were gleaned from either expert opinions or the experiences obtained from ED overcrowding  
262 studies.<sup>12,21,22</sup> Twenty different operational variables and 5 indices were included in this derivation study (see table 1)  
263 in order to match the requirements of the different UCC settings. The majority of these variables were similar to the  
264 ones used in ED overcrowding studies,<sup>12</sup> except 1) the numbers of patients triaged to ESI levels 1 and 2 were not  
265 considered due to significantly fewer presentations of these patients to the UCC resulting in insufficient power to  
266 perform statistical analysis; 2) the numbers of critical care patients which would be transferred to intensive care  
267 settings relatively quickly. On the other hand, the number of APPs on duty and the number of patients waiting in the  
268 results pending area were added for investigation particularly in this study because 1) the majority of UCC settings  
269 have APPs, and 2) the majority of UCC patients do not present with conditions requiring a monitored bed. The  
270 overwhelming majority of patients presenting to an UCC can be safely managed in a non-monitored area while  
271 awaiting diagnostic results and/or receiving medications thereby releasing exam beds for new patients.

272 Our results showed that 4 different independent variables could affect the UCC overcrowding status. These  
273 variables include total patient index, number of results pending patents, waiting room patient index, and the longest  
274 time in hours of patients in the waiting room. Two variables (total patient index and the longest time in hours of  
275 patients in the waiting room) have also been used to evaluate ED overcrowding in previous studies<sup>12</sup>. The number of  
276 patients triaged at an acuity level of ESI-3 or its equivalent in the waiting room has shown to affect ED  
277 overcrowding in previous studies. These patients accounted for the majority of patients waiting for an initial  
278 provider encounter when the ED was determined to be overcrowded.<sup>23,24</sup> Different conditions may occur in the UCC  
279 setting. The majority of UCC patients in the waiting room will be ESI-4 and 5 level patients. Considering that ESI-1  
280 and 2 patients will be transferred out of an UCC to a higher acuity setting, ESI-3 patients are therefore the highest  
281 priority patients to be seen in the average UCC. It is therefore appropriate to consider the waiting room patient index  
282 as an independent variable for UCC overcrowding evaluation. The number of results pending patients is another  
283 variable that is similar with respect to vertical flow patients at an ED.<sup>25</sup> Briefly, patients presenting to an ED that are  
284 determined not to require a monitored bed are often processed through a pathway involving minimal time spent in  
285 an exam room followed by the majority of their time in a results pending area awaiting diagnostics, medications  
286 delivery, and re-evaluation. This is a recognized method to reduce ED overcrowding and has been reported in other  
287 studies.<sup>25-27</sup> In a busy UCC, this method is also employed to effectively manage UCC patient flow.

288 SONET was derived in this study to estimate UCC overcrowding. Three different levels of crowding were  
289 developed to include severely overcrowded, overcrowded, and not overcrowded. The ranges of the SONET score for  
290 the different crowding statuses match those of NEDOCS (national emergency department overcrowding study)  
291 which is widely used nationally<sup>12</sup>. UCC workflow is considered efficiently managed at an appropriate level when the  
292 SONET score falls under the not overcrowded threshold. When the overcrowding threshold is approached UCC and  
293 hospital administrators are alerted of the high potential for severely overcrowding and to employ pre-determined  
294 actions to avoid reaching a severely overcrowded status. When operational outcomes were measured in this study, it  
295 confirmed the importance of dividing relative overcrowding into these three categories. The number of LWBS  
296 patients and the average LOS of ESI levels 4 and 5 patients increased with the severity of UCC crowding. There was  
297 an average of 22 minutes increase in ESI level 3 patients when UCC was deemed to be severely overcrowded as  
298 compared with a determination of overcrowded though no statistically significant difference was appreciated. This  
299 was in part due to a tendency for more ESI level 3 patients being transferred out of UCC under severely  
300 overcrowded conditions (data not shown). As previously mentioned average LOS among ESI levels 1 and 2 patients  
301 was not a contributing factor in this study as this cohort of patients is not treated in the lower acuity setting of an  
302 UCC. When total LOS is viewed as a function of relative crowding status significantly prolonged delay to patient  
303 placement in an exam room was notable and is consistent with previous reports.<sup>26,27</sup>

1  
2  
3 304 Overall, a novel tool is derived to determine UCC overcrowding status and our findings also show the severity of  
4 305 overcrowding could link to the negative patient outcomes. Based on the results of this study, future research can be  
5 306 focused on external validations in different UCC settings.

7 307

### 10 308 **Limitations**

11  
12 309 This study was performed in a single urban UCC affiliated with a publicly funded hospital system which could  
13 310 inevitably have population selection bias and limit its use in a more general setting. Considering the study was  
14 311 performed in a relatively high volume UCC setting, this crowding estimation tool might only accurately reflect  
15 312 conditions typically encountered in a similar setting. In addition, the study facility has an emergency psychiatric unit  
16 313 which directly and indirectly accepts patients with urgent and emergent psychiatric conditions. As such very few  
17 314 patients with psychiatric problems present to UCC resulting in a potential bias in terms of population selection.  
18 315 Therefore, results of this study need to be validated in a multicenter study involving different UCC settings and  
19 316 populations. Operational variables chosen in this study were based upon previous ED overcrowding studies and  
20 317 expertise recommendations, As such other variables that potentially affect UCC crowding might have been missed.  
21 318 During our study period, the process of triaging a low acuity (ESI levels 4 and 5) ED patient to UCC when the ED is  
22 319 determined to be severely overcrowded was not yet initiated. Therefore, the number of patients transferred from ED  
23 320 to UCC was not considered a risk factor impacting UCC crowding. Furthermore, consideration of average LOS and  
24 321 numbers of LWBS patients as the only patient care outcome measurements may not be enough to determine the  
25 322 most accurate association to UCC crowding. Other patient care outcome variables such as 72h UCC/ED returns,  
26 323 patient satisfaction, and nosocomial accidents might need to be included.

28 324

### 30 325 **Conclusion**

31  
32 326 An overcrowding estimation tool (SONET) used to determine relative crowding status in a high volume UCC setting  
33 327 was derived in this study. The study also showed that UCC overcrowding is associated with negative patient care  
34 328 outcomes.

37 329

39 330 **Competing Interests:** N/A

41 331

42  
43 332 **Author contributions:** HW and RDR conceived the study and developed the design in consultation with all of the  
44 333 authors. CDC<sup>1</sup>, VAG, and CDC<sup>2</sup> assembled the data set and collected the data. HW, RDR, EKG, CDS, RDJ, and  
45 334 NRZ conducted the statistical analyses and drafted the article, and all authors read and approved the final manuscript.  
46 335 HW takes responsibility for the paper as a whole. (1: CDC: Chad D. Cowden; 2: CDC: Christopher D. Cook)

49 336

50  
51 337 **Acknowledgement:** We would like to thank all the UCC attending physicians, APPs, nursing staff, and unit clerks  
52 338 participating in this study.

54 339

56 340 **Table legend:**

341 Table 1 shows the clinical and operational variables and index collected in the UCC overcrowding study. There  
 342 were total 20 individual operational variables and 5 indexes collected based on the previous ED overcrowding study  
 343 and expertise's opinions.

344 Table 2 shows the general information of patients in this study

345 Table 3 shows the average LOS of patients who registered at UCC under the different crowding statuses determined  
 346 by the SONET.

347 Table 4 shows the average time spend at different stages in patients who registered at UCC under the different  
 348 crowding statuses determined by the SONET

349 Appendix table shows the average LOS of discharged patients who registered at UCC under the different crowding  
 350 statuses determined by the SONET

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For peer review only

## STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	<p>(a) Indicate the study’s design with a commonly used term in the title or the abstract</p> <p>(b) Provide in the abstract an informative and balanced summary of what was done and what was found</p> <p><i>Explanation: a) <b>Yes</b>. This is a prospective study and was reported in the abstract section. b) <b>Yes</b>. In abstract, clearly addressed what was done and in result section, the findings were also reported.</i></p>
<b>Introduction</b>		
Background/rationale	2	<p>Explain the scientific background and rationale for the investigation being reported</p> <p><i><b>Yes, we address the scientific background and the rationale for this study.</b></i></p>
Objectives	3	<p>State specific objectives, including any prespecified hypotheses</p> <p><i><b>Yes, in the end of the introduction section, we reported a specific urgent care center overcrowding estimation tool will be derived and study primary and secondary goals (hypotheses)</b></i></p>
<b>Methods</b>		
Study design	4	<p>Present key elements of study design early in the paper</p> <p><i><b>Yes, study design was reported in Line 70.</b></i></p>
Setting	5	<p>Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection</p> <p><i><b>Yes, location: Line 71-72, periods of recruitment: Line 87, exposure, follow-up: Line 78-84, this study did not require follow-up. Data collection: Line 111-154.</b></i></p>
Participants	6	<p><i>Cohort study</i>—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up</p> <p><i><b>Yes, Line 78-84, this study did not require follow up.</b></i></p>
Variables	7	<p>Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable</p> <p><i><b>Yes, see section Variables: Line 111-138 and table 1.</b></i></p>
Data sources/ measurement	8*	<p>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</p> <p><i><b>Yes, see section Variables: Line 111-138 and table 1.</b></i></p>
Bias	9	<p>Describe any efforts to address potential sources of bias</p> <p><i><b>Yes, single center study with population selection bias will be inevitably occurred and this is addressed in our limitation section.</b></i></p>
Study size	10	<p>Explain how the study size was arrived at</p> <p><i><b>Yes, line 73-75.</b></i></p>
Quantitative variables	11	<p>Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why</p> <p><i><b>Yes, three groups were divided in this study (N: not overcrowding; O: overcrowding; and S: severely overcrowding groups) and outcome measurements were compared with these three groups. See Line 145-154. How quantitative variables were handled</b></i></p>

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2 *in the analyses were also addressed in the statistics section See Line 166-171.*

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3 Statistical methods 12 (a) Describe all statistical methods, including those used to control for confounding

4 (b) Describe any methods used to examine subgroups and interactions

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5 (c) Explain how missing data were addressed

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6 (d) *Cohort study*—If applicable, explain how loss to follow-up was addressed

7 *Yes, a): statistical methods addressed in detail in Line 155-172. b): see Line 166-170.*

8 *c) see line 78-84. d) this study did not require any follow-up.*

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9 (e) Describe any sensitivity analyses

10 N/A: no sensitivity analyses addressed in this study since there is no standard or

11 previous similar study reported. However, consider the perceptions of overcrowding

12 of healthcare providers as a “gold standard”, inter-rater reliability between the

13 SONENT scores and provider perceptions was measured. Line 197-200

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**Results**

Participants	13*	<p>Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed.</p> <p><i>Yes, see line 202-205. Table 2</i></p> <hr/> <p>Give reasons for non-participation at each stage</p> <p><i>Yes, see line 202-203</i></p> <hr/> <p>Consider use of a flow diagram</p> <p><i>No, since this is very easy to address in the manuscript, no flow diagram drawn.</i></p>
Descriptive data	14*	<p>(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders</p> <p><i>Yes, see Table 2.</i></p> <hr/> <p>(b) Indicate number of participants with missing data for each variable of interest</p> <p><i>Yes, see line 179-180, and 202-205.</i></p> <hr/> <p>(c) Cohort study—Summarise follow-up time (eg, average and total amount)</p> <p><i>No, this study did not require follow-up.</i></p>
Outcome data	15*	<p>Cohort study—Report numbers of outcome events or summary measures over time</p> <hr/> <p>Case-control study—Report numbers in each exposure category, or summary measures of exposure</p> <hr/> <p>Cross-sectional study—Report numbers of outcome events or summary measures</p> <p><i>Yes, see result section: outcome measurements Line 201-244.</i></p>
Main results	16	<p>(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included</p> <p><i>Yes, see Line 184-196. Results showed only 4 variables can be independent variables while others are the confounding factors.</i></p> <hr/> <p>(b) Report category boundaries when continuous variables were categorized</p> <p><i>Yes, continuous variables are converted to categorical variables based on the results of previous study. See line 90-96.</i></p> <hr/> <p>(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period</p> <p><i>N/A</i></p>
Other analyses	17	<p>Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses</p> <p><i>Yes, see Table 4 and Appendix Table.</i></p>
<b>Discussion</b>		
Key results	18	<p>Summarise key results with reference to study objectives</p> <p><i>Yes, see Line 247-256.</i></p>
Limitations	19	<p>Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias</p> <p><i>Yes, see limitation section Line 302-317.</i></p>
Interpretation	20	<p>Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence</p> <p><i>Yes, see discussion Line 257-300.</i></p>
Generalisability	21	<p>Discuss the generalisability (external validity) of the study results</p> <p><i>Yes, internal validation performed and no external validation reported in this study and also</i></p>

addressed in the limitation. see Line 200, 310-311.

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
		N/A

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

For peer review only

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## Use of the SONET Score to Evaluate Urgent Care Center Overcrowding: A Prospective Pilot Study

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1 Title Page:

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3 Title: Use of the SONET Score to Evaluate Urgent Care Center Overcrowding: A Prospective Pilot Study

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14 Key words: Urgent care center, Crowding, Tool, Patient care outcome

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16 Word count: 3869

# 17 Use of the SONET Score to Evaluate Urgent Care Center Overcrowding: A Prospective Pilot

## 18 Study

### 19 **Abstract**

20 **Objectives:** To derive a tool to determine Urgent Care Center (UCC) crowding and investigate the association  
21 between different levels of UCC overcrowding and negative patient care outcomes.

22 **Design:** Prospective pilot study

23 **Setting:** Single center study in USA.

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25 **Participants:** 3,565 patients that registered at UCC during the 21 day study period were included. Patients who had  
26 no overcrowding statuses estimated due to incomplete collection of operational variables at the time of registration  
27 were excluded in this study. 3,139 patients were enrolled in the final data analysis.

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29 **Primary and secondary outcome measures:** A crowding estimation tool (SONET: Severely overcrowded,  
30 Overcrowded, and Not overcrowded Estimation Tool) was derived using the linear regression analysis. The average  
31 length of stay (LOS) in UCC patients and the number of left without being seen (LWBS) patients were calculated  
32 and compared under the three different levels of UCC crowding.

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34 **Results:** Four independent operational variables could affect the UCC overcrowding score including the total  
35 number of patients, the number of results pending patients, the number of patients in the waiting room, and the  
36 longest time a patient was stationed in the waiting room. In addition, UCC overcrowding was associated with  
37 longer average LOS (not overcrowded: 133±76min, overcrowded: 169±79min, and severely overcrowded:  
38 196±87min, p<0.001) and an increased number of LWBS patients (not overcrowded: 0.28±0.69 patients,  
39 overcrowded: 0.64±.98, and severely overcrowded: 1.00±0.97).

40 **Conclusions:** The overcrowding estimation tool (SONET) derived in this study might be used to determine  
41 different levels of crowding in a high volume UCC setting. It also showed UCC overcrowding might be associated  
42 with negative patient care outcomes.

43 **Key Words:** Urgent care center, Crowding, Tool, Patient care outcome

44 **Strengths and Limitations of this study:** Strengths: 1) the first prospective study on urgent care overcrowding, 2)  
45 the first study reported the link with the overcrowding and patient outcome in the urgent care setting, 3) derived a  
46 new overcrowding scoring system for urgent care crowding estimation which has not reported before. Limitations: 1)  
47 single center study requiring external validation; 2) special population selection could lead to selection bias.

### 48 **Introduction**

49 As the demand for real time access to care increases, Emergency Department (ED) overcrowding has become more  
50 and more common in recent years.<sup>1,2</sup> One of the solutions to ED overcrowding is to reduce the numbers of low  
51 acuity patients presenting for care.<sup>3,4</sup> It is reported that hospitals are adding their own or partnering with existing  
52 non-hospital based urgent care centers (UCCs) to offset ED overcrowding.<sup>5,6</sup> According to the report from the  
53 Urgent Care Association of America, the number of UCCs has increased over 12% within 3 years and it has  
54 provided care to over 3 million patient visits every week.<sup>7</sup> UCCs are now recognized as providing convenient, less  
55 expensive access to care as compared to that experienced at an average ED.

56 In primary care settings, the gap of available providers is expected to continue to grow. The primary care setting  
57 workload is expected to increase by 29% from 2005 to 2025. Meanwhile the number of primary care providers is  
58 expected to grow by only 2%-7% during the same timeframe.<sup>8,9</sup> Given the prediction that both ED and primary care

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3 59 settings will continue to be resource constrained, a proactive approach to anticipating UCC overcrowding will offer  
4 60 a means to mitigate patient care risk. To the best of our knowledge, no UCC overcrowding estimation tool has been  
5 61 reported to date.

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7 62 Accurately estimating UCC overcrowding will not only help reduce ED overcrowding but will also alert  
8 63 administrators to take action by mobilizing resources as an overcrowded condition becomes imminent thereby  
9 64 minimizing the risk of undesirable patient care outcomes.<sup>10,11</sup> The primary goal of this study is to derive a suitable  
10 65 tool we named SONET (Severely overcrowded – Overcrowded – Not overcrowded Estimation Tool) to evaluate  
11 66 overcrowding in a high volume UCC setting. A secondary goal is to determine the association between UCC  
12 67 overcrowding and negative patient care outcomes.

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17 69 **Materials and Methods**

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19 70 **Study design and Patient population:**

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21 71 This was a prospective pilot study designed to derive an estimation tool to determine overcrowding status in a  
22 72 moderate to high volume UCC setting. This study was carried out at a publicly funded health system that has both  
23 73 ED and UCC at different locations within the main campus and with separate triage systems. The annual volume of  
24 74 the study UCC is approximately 62,000 visits. Considering no previous UCC overcrowding study reported and no  
25 75 historical data available for sample size estimation, the same study period used for Emergency Department  
26 76 overcrowding study was used in this study.<sup>12</sup> The John Peter Smith Health Network Institutional Review Board  
27 77 approved the study (IRB approval number: 110413.003ex).

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32 79 All patients that registered initially at UCC were included in this study. Patients were triaged by dedicated nurses at  
33 80 the triage encounter point and individual patient acuity levels were then assigned by using the Emergency Severity  
34 81 Index (ESI). ESI is a standardized ED/UCC triage system confirmed to be a reliable and valid triage system in US to  
35 82 determine the different acuity levels upon each patients' entry into the service.<sup>13</sup> Patients with potentially higher  
36 83 levels of acuity (e.g. ESI 1 and 2) are routed to a physician immediately. Physician discretion is employed to  
37 84 determine if these patients need to transfer to ED for further emergent evaluation and treatment. Those patients at  
38 85 ESI levels 1 and 2 who were not sent to the ED remain in the urgent care workflow. Patients who had no  
39 86 overcrowding statuses estimated due to incomplete collection of operational variables at the time of registration  
40 87 were excluded in this study.

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44 89 **Study protocol**

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46 90 This study was carried out from Feb 24, 2014 through Mar 16, 2014. During these 21 days, all physicians, advanced  
47 91 practice providers (APP), charge nurses, flow coordinator nurses, and triage nurses were called separately every two  
48 92 hours by a dedicated UCC clerk and asked to report their perception of the current UCC crowding status. The UCC  
49 93 clerk was blinded to this study. The perceptions of UCC overcrowding were rated on a 0-100mm visual analogue  
50 94 scale (VAS). UCC overcrowding was considered to be true if the score on the VAS  $\geq 50$  and was considered  
51 95 severely overcrowded if the score on the VAS  $\geq 70$ . An average UCC overcrowding score was then calculated.  
52 96 Since no UCC overcrowding scale was reported before, our study overcrowding score was multiplied by a factor of  
53 97 2 in order to match an ED overcrowding scale that is widely used nationally.<sup>12</sup> A score  $\geq 100$  was considered  
54 98 overcrowded and  $\geq 140$  was considered severely overcrowded. Therefore, three different crowding statuses were  
55 99 considered: not-overcrowded, overcrowded, and severely overcrowded.

100 UCC opens at 0600 and closes around 2300 during weekdays. During the weekend, UCC opens at 0600 but closes at  
 101 variable times depending on the volume of patients presenting during the course of the day. UCC triage ends at 2200.  
 102 Patients who present after 2200 are redirected to ED for further evaluation and treatment. UCC closes after the last  
 103 patient's disposition which is usually around 2300. The perception of UCC crowding status was queried 8 times  
 104 each day during the weekdays at 0700, 0900, 1100, 1300, 1500, 1700, 1900, and 2100 separately. During the  
 105 weekend, queries occurred at 0700 and then every 2 hours until UCC closed. Patients who registered between 0600  
 106 and 0700 were considered under the not-overcrowded category.

107 At the same time provider perceptions of UCC crowding were asked by the UCC clerk, all variables were also  
 108 recorded simultaneously by that clerk who did not participate in this study. The clinical or operational variables  
 109 considered to potentially affect UCC crowding were collected after discussion with a group of those with  
 110 operational expertise. A scoring tool to determine UCC crowding was then derived from the study that we named  
 111 SONET (Severely-overcrowded Overcrowded Not-overcrowded Estimation Tool). Additionally, 1,000 sample  
 112 randomized data sets were employed to validate the study internally by using the bootstrap methods.

113

#### 114 Variables

115 The total number of UCC beds was used as a constant in this study. All the other clinical or operational variables  
 116 such as the total number of patients at UCC, the number of patients in the waiting room, the number of attending  
 117 physicians, APPs, and nurses on duty, the number of patients with different Emergency Severity Index (ESI) levels,  
 118 and the longest wait time of those patients in the waiting room at the time of scoring were also collected (see Table  
 119 1). In order to potentially apply the SONET scoring system to different UCC settings, several indices were  
 120 calculated as well. The total patient index was the total number of patients at UCC divided by the number of UCC  
 121 beds. The waiting room patient index was the number of patients in the waiting room divided by the number of UCC  
 122 beds. The results pending patient index was the total number of results pending patients (e.g. patients already seen  
 123 by healthcare providers at UCC and then placed in the result pending area) divided by the number of active patients  
 124 (e.g. active patients were the total number of UCC registered patients less the number of patients in the waiting  
 125 room). The physician index was the total number of patients at UCC divided by the number of physicians on duty.  
 126 The nurse index was the total number of patients at UCC divided by the number of nurses on duty. The APP index  
 127 was the total number of patients at UCC divided by the number of APPs on duty.

128

129 Table 1. Clinical and operational variables and indices collected in the UCC overcrowding study

Variables		
The total number of patients at UCC	The number of patients already transferred to other facilities in the past two hours	The number of physicians on duty
Total number of patients in the waiting room	The number of patients with ESI 1 or 2 transferred to other facilities in the past two hours	The number of nurses on duty
The number of patients in the results pending area	The number of patients waiting to be transferred to other facilities	The number of APPs on duty
The number of patients with different assigned acuity levels (ESI 1, 2, 3, 4, 5)	The number of patients waiting to be discharged	The number of triage nurses on duty
The number of patients with different assigned acuity levels in the waiting room (ESI 3, 4, 5)	The longest wait time among patients in the waiting room expressed in hours	
Index		
Total patient index	Results pending patient index	Waiting room patient index

Nurse index	APP index	Physician index
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Abbreviations: UCC urgent care center, ESI: emergency severity index, APP: advanced practice provider. The number of patients in the results pending area refers to the number of patients that had already been seen by a healthcare provider and were awaiting results of diagnostic testing. After initial provider interview and physical exam these patients are relocated from the exam room to the results pending area. The total patient index is the total number of patients at UCC divided by the number of UCC beds. The results pending patient index is the total number of patients residing in the results pending status (e.g. patients already seen by healthcare providers at UCC and then transitioned to the results pending area) divided by the number of active patients (e.g. active patients were the total number of patients in UCC less those patients in the waiting room). The waiting room patient index was the number of patients in the waiting room divided by the number of UCC beds. The nurse index was the total number of patients at UCC divided by the number of nurses on duty. The APP index was the total number of patients at UCC divided by the number of APPs on duty. The physician index was the total number of patients at UCC divided by the number of physicians on duty.

#### Outcome measurement

The SONET score was derived after the study was completed and retrospectively entered into the study data. All patients during the study period were assigned to have SONET scores at the time the patients were registered in the UCC and stratified into three different crowding categories. Patients who registered at UCC with incomplete data were excluded from the study as their individual SONET scores could not be calculated.

In order to know whether UCC overcrowding potentially affects UCC operational efficiency, LOS and the number of LWBS patients were used as markers for UCC efficiency measurements. UCC LOS refers to the interval of time starting with initial UCC patient registration and ending at the point when a patient is physically discharged from the UCC track board. For LWBS patients, the LOS was calculated as the interval of time starting with initial UCC registration and ending at the point that no response to a call for further service was documented. We performed three calls to every LWBS patient in a twenty minutes interval. If no response was received after the third call, the patient was considered LWBS and the time of the first call was recorded as the documented time of no response. All patients registered for UCC services during the study period were included in the data analysis. Patient care outcomes were compared among these three groups (not-overcrowded, overcrowded, and severely overcrowded groups).

#### Data analysis and Statistics

A linear regression model was applied and the independent operational variables that could affect UCC overcrowding status scores were determined. Correlation coefficient (r) was analyzed on each operational variable with its scatter plot drawn. Variables that had strong correlation ( $r > 0.6$ ) with UCC crowding were chosen for linear regression analysis. Variance inflation factor (VIF) quantifies the severity of multi-collinearity in the regression model analysis thereby providing an index to estimate whether the regression coefficient is increased due to collinearity. Operational variables with high VIF ( $> 10$ ) were considered as having collinearity and were therefore excluded from regression analysis.<sup>14,15</sup> A formula was then generated based on the regression coefficient of each independent operational variable and an UCC crowding score was calculated. A bootstrap technique that randomized 1,000 samples was used to internally validate the study score accuracy.

Considering the operational significance of determining UCC overcrowding status, the SONET score was divided into three categories: not overcrowded (score  $< 100$ ), overcrowded (score between 100 and 140, including 100 but not including 140), and severely overcrowded (score  $\geq 140$ ). Patients were automatically assigned to three groups based on ED overcrowding scores at the time when a specific patient registered for services in the UCC. To compare the

173 differences between LWBS, and LOS at UCC relative to the different UCC overcrowding status groups, analysis of  
 174 variance (ANOVA) with Bonferroni correction was used to analyze differences between groups.

175 All statistical analysis was performed using STATA 12 (College Station, TX) and a  $p < 0.05$  was considered a  
 176 statistically significant difference.

177

## 178 Results

### 179 Derivation of SONET scoring system

180 The prospective pilot study was performed from 0600 on Feb 24, 2014 until 1900 on Mar. 16, 2014 which included  
 181 15 weekdays and 6 weekend days. The UCC closes operations at different times during the weekends resulting in 36  
 182 data sets collected at different time points. Therefore, there were a total of 134 data sets collected resulting in a data  
 183 completion rate of 85.9% (134/156). Among these 134 time points, the UCC was determined by healthcare provider  
 184 perceptions to be below the not-overcrowded threshold 57.46% (77/134) of the time. The UCC was determined to be  
 185 below the overcrowded threshold 26.12% (35/134) of the time and below the severely overcrowded threshold 16.42%  
 186 (22/134) of the time.

187 Results of linear regression showed only 4 variables that can be considered independent risk factors affecting the  
 188 UCC crowding status. These are total number of patients, number of results pending patients, number of patients in  
 189 the waiting room, and longest wait time of patients in the waiting room. Other variables reached either no statistical  
 190 significance, had no correlation with overcrowding, or had significant colinearity with a VIF (variance inflation  
 191 factor) greater than 10. In order to suitably apply the tool with respect to different UCC settings, total patient index  
 192 and waiting room patient index were used. Therefore a UCC crowding scoring formula (SONET) was derived and is  
 193 defined as:

194 SONET Score = 24.5 x total patient index + 58.1 x waiting room patient index + 2.7 x number of result pending  
 195 patients + 12.2 x the longest time in hours of patient in the waiting room + 32.4. (in short form: SONET Score =  
 196 24.5T+58.1WI+2.7R+12.2L+32.4 (TWIRL) where T indicates the total patients index, WI indicates the waiting  
 197 room patient index, R indicates the number of results pending patients in UCC, and L indicates the longest time in  
 198 hours of patients in the waiting room). SONET score  $\geq 100$  is considered UCC overcrowded and  $\geq 140$  is considered  
 199 severely overcrowded.

200 Using the average perceptions of UCC crowding status among different healthcare providers as a “gold standard”  
 201 demonstrated strong inter-rater reliability between the SONET scores and provider perceptions when compared  
 202 within the three different crowding statuses (not overcrowded, overcrowded, and severely overcrowded,  $\kappa=0.6446$ ).  
 203 Internal validation using bootstrap methods showed similar results (data not shown).

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### 205 Outcome measurement

206 A total of 3,565 patients were registered to receive services in the UCC during the study period. Excluding patients  
 207 who had no SONET scores calculated due to incomplete collection of operational variables at the time of  
 208 registration, 3,139 patients were enrolled in data analysis. The general information of these patients is shown in  
 209 Table 2.

210 Table 2. General Information of Patients in the study

Age (year $\pm$ SD)	41.97 $\pm$ 15.57 (95%CI 41.43-42.52)
Gender (male, %)	46.70%

Level of Acuity (% , number)	
ESI1	0.16% (5)
ESI2	5.61% (176)
ESI3	24.94% (783)
ESI4	59.64% (1,872)
ESI5	8.00% (251)
unknown	1.66% (52)
Disposition (% , number)	
Discharged	89.58% (2812)
Admitted	4.17% (131)
LWBS	1.94% (61)
Average time intervals (min±SD)	
from patient arrival to triage	7.9±7.0 (95% CI 7.6-8.1)
from patient arrival to placement in an exam room	42.6±41.4 (95% CI 41.2-44.1)
from patient arrival to patient initial encounter with a healthcare provider	75.9±56.6 (95% CI 74.0-77.9)
from patient arrival to disposition (discharge vs. admit) rendered	132.5±82.7 (95% CI 129.6-135.4)
from patient arrival to patient departure from UCC	151.6±89.5 (95%CI 148.5-154.7)

In order to determine whether the UCC overcrowding status could affect UCC operational efficiency and safety, LOS and LWBS were investigated. Patients registered at UCC triage during the study period were assigned to three different UCC crowding statuses determined by SONET scores (N: not overcrowded; O: overcrowded; and S: severely overcrowded).

The average LOS at UCC under each crowding status determined by SONET reached statistically significant differences between groups. Similar results were found when patients were further subdivided into the different ESI level groups (Table 3). The more severe the crowding score in the UCC, the longer the average LOS of all patients, especially those triaged to ESI levels 3, 4, and 5. When analyzing only discharged patients, similar results were found with statistically significant differences among groups (Appendix Table). To more accurately determine the effects of UCC crowding status on delayed patient care LOS was divided into several segments. The segments were time spent at triage, wait time for an available exam room, wait time to arrival of a healthcare provider, and wait time to disposition (Table 4). The results of our study showed that the most significant delay in care occurred during the period while patients awaited an available exam room. No significant difference was noted after patients were initially seen by the healthcare providers.

Table 3. The average LOS of patients who registered at UCC as a function of relative acuity status and SONET score

	Average LOS of Patients at UCC (min±SD, number of patients)					
	All patients	ESI-1	ESI-2	ESI-3	ESI-4	ESI-5
Not Overcrowded	130±80 (1581)	57±67 (2)	59±56 (69)	136±95 (385)	139±73 (981)	93±47 (125)
Overcrowded	165±88 (957) *p<0.001	58±55 (3) *p=0.973	71±62 (58) *p=0.733	170±102 (242) *p<0.001	181±79 (549) *p<0.001	139±53 (87) *p<0.001
Severely Overcrowded	186±97 (601) **p<0.001		57±48 (49) **p=0.699	192±114 (156) **p=0.112	208±75 (342) **p<0.001	187±83 (39) **p<0.001

231 Abbreviation: LOS: length of stay (time interval from initial patient registration to departure from UCC); UCC:  
 232 urgent care center; SD: standard deviation; ESI: Emergency Severity index. \*: comparison between not overcrowded  
 233 and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

234 Table 4. Patient encounter average time intervals as a function of relative crowding status determined by the SONET  
 235 score

	Average time spend of Patients at different phases (min±SD)					
	Arrival to Triage	Triage encounter	Triage to patient placed in an exam room	Patient placed in an exam room to patient seen by a healthcare provider	Patient seen by a healthcare provider to disposition decision	Disposition decision to patient departure from UCC
Not overcrowded	6.8±6.4	2.3±2.2	17.4±25.7	30.3±30.7	54.8±57.5	19.6±17.4
Overcrowded	7.9±6.8 *p<0.001	2.5±2.2 *p=0.097	38.5±35.6 *p<0.001	39.4±33.8 *p<0.001	56.1±63.0 *p=1.000	21.0±20.8 *p=0.267
Severely Overcrowded	10.6±8.1 **p<0.001	2.8±2.5 **p=0.210	60.9±52.7 **p<0.001	31.3±30.0 **p<0.001	57.6±69.2 **p=1.000	21.3±21.0 **p=1.000

236 Abbreviation: UCC: urgent care center; SD: standard deviation. \*: comparison between not overcrowded and  
 237 overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups

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239 LWBS data was collected every two hours. The numbers of LWBS patients was  $0.28\pm 0.69$  every two hours if UCC  
 240 was under a not-overcrowded status,  $0.64\pm 0.98$  when at an overcrowded status, and  $1.00\pm 0.97$  when at a severely  
 241 overcrowded status. The results show the numbers of LWBS patients were associated with the severity of UCC  
 242 crowding as determined by the SONET scores however not sufficiently powered to reach statistical significance  
 243 ( $p>0.05$ ).

244

## 245 Discussion

246 Providing urgent care services to meet the needs of the evolving healthcare consumer is gaining considerable  
 247 interest by the industry. The number of UCC patients has increased substantially every year resulting in the potential  
 248 for UCC saturation and resultant overcrowding. To date no UCC overcrowding estimation tool was available.<sup>16,17</sup> In  
 249 order to maintain a high standard of clinical and operational performance in the urgent care setting, assessment of  
 250 UCC overcrowding is critical to effective management. Much research has been done on ED overcrowding, but  
 251 minimal attention has been paid to overcrowding as it relates to UCC workflow.<sup>18-20</sup> Our institution operates both an  
 252 ED and UCC at different locations with different triage system providing us an opportunity to investigate  
 253 overcrowding at each discreet location. In this study, a UCC overcrowding estimation tool (SONET) was derived  
 254 and also showed the prolonged average LOS and increased number of LWBS patients linked closely with the  
 255 severity levels of UCC overcrowding.

256 Since no UCC overcrowding tool has been reported, the operational variables chosen for deriving our UCC  
 257 overcrowding tool were gleaned from either expert opinions or the experiences obtained from ED overcrowding  
 258 studies.<sup>12,21,22</sup> Twenty different operational variables and 5 indices were included in this derivation study (see table 1)  
 259 in order to match the requirements of the different UCC settings. The majority of these variables were similar to the  
 260 ones used in ED overcrowding studies,<sup>12</sup> except 1) the numbers of patients triaged to ESI levels1 and 2 were not  
 261 considered due to significantly fewer presentations of these patients to the UCC resulting in insufficient power to  
 262 perform statistical analysis; 2) the numbers of critical care patients which would be transferred to intensive care

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263 settings relatively quickly. On the other hand, the number of APPs on duty and the number of patients waiting in the  
264 results pending area were added for investigation particularly in this study because 1) the majority of UCC settings  
265 have APPs, and 2) the majority of UCC patients do not present with conditions requiring a monitored bed. The  
266 overwhelming majority of patients presenting to an UCC can be safely managed in a non-monitored area while  
267 awaiting diagnostic results and/or receiving medications thereby releasing exam beds for new patients.

268 Our results showed that 4 different independent variables could affect the UCC overcrowding status. These  
269 variables include total patient index, number of results pending patients, waiting room patient index, and the longest  
270 time in hours of patients in the waiting room. Two variables (total patient index and the longest time in hours of  
271 patients in the waiting room) have also been used to evaluate ED overcrowding in previous studies<sup>12</sup>. The number of  
272 patients triaged at an acuity level of ESI-3 or its equivalent in the waiting room has shown to affect ED  
273 overcrowding in previous studies. These patients accounted for the majority of patients waiting for an initial  
274 provider encounter when the ED was determined to be overcrowded.<sup>23,24</sup> Different conditions may occur in the UCC  
275 setting. The majority of UCC patients in the waiting room will be ESI-4 and 5 level patients. Considering that ESI-1  
276 and 2 patients will be transferred out of an UCC to a higher acuity setting, ESI-3 patients are therefore the highest  
277 priority patients to be seen in the average UCC. It is therefore appropriate to consider the waiting room patient index  
278 as an independent variable for UCC overcrowding evaluation. The number of results pending patients is another  
279 variable that is similar with respect to vertical flow patients at an ED.<sup>25</sup> Briefly, patients presenting to an ED that are  
280 determined not to require a monitored bed are often processed through a pathway involving minimal time spent in  
281 an exam room followed by the majority of their time in a results pending area awaiting diagnostics, medications  
282 delivery, and re-evaluation. This is a recognized method to reduce ED overcrowding and has been reported in other  
283 studies.<sup>25-27</sup> In a busy UCC, this method is also employed to effectively manage UCC patient flow.

284 SONET was derived in this study to estimate UCC overcrowding. Three different levels of crowding were  
285 developed to include severely overcrowded, overcrowded, and not overcrowded. The ranges of the SONET score for  
286 the different crowding statuses match those of NEDOCS (national emergency department overcrowding study)  
287 which is widely used nationally<sup>12</sup>. UCC workflow is considered efficiently managed at an appropriate level when the  
288 SONET score falls under the not overcrowded threshold. When the overcrowding threshold is approached UCC and  
289 hospital administrators are alerted of the high potential for severely overcrowding and to employ pre-determined  
290 actions to avoid reaching a severely overcrowded status. When operational outcomes were measured in this study, it  
291 confirmed the importance of dividing relative overcrowding into these three categories. The number of LWBS  
292 patients and the average LOS of ESI levels 4 and 5 patients increased with the severity of UCC crowding. There was  
293 an average of 22 minutes increase in ESI level 3 patients when UCC was deemed to be severely overcrowded as  
294 compared with a determination of overcrowded though no statistically significant difference was appreciated. This  
295 was in part due to a tendency for more ESI level 3 patients being transferred out of UCC under severely  
296 overcrowded conditions (data not shown). As previously mentioned average LOS among ESI levels 1 and 2 patients  
297 was not a contributing factor in this study as this cohort of patients is not treated in the lower acuity setting of an  
298 UCC. When total LOS is viewed as a function of relative crowding status significantly prolonged delay to patient  
299 placement in an exam room was notable and is consistent with previous reports.<sup>26,27</sup>

300 Overall, a novel tool is derived to determine UCC overcrowding status and our findings also show the severity of  
301 overcrowding could link to the negative patient outcomes. Based on the preliminary results of this study, a multi-  
302 center prospective study that focused on external validations and outcome measurements in different UCC settings  
303 has already been started.

304

305 **Limitations**

306 This study was performed in a single urban UCC affiliated with a publicly funded hospital system which could  
307 inevitably have population selection bias and limit its use in a more general setting. Considering the study was  
308 performed in a relatively high volume UCC setting, this crowding estimation tool might only accurately reflect  
309 conditions typically encountered in a similar setting. In addition, the study facility has an emergency psychiatric unit  
310 which directly and indirectly accepts patients with urgent and emergent psychiatric conditions. As such very few

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3 311 patients with psychiatric problems present to UCC resulting in a potential bias in terms of population selection.  
4 312 Therefore, results of this study need to be validated in a multicenter study involving different UCC settings and  
5 313 populations. Operational variables chosen in this study were based upon previous ED overcrowding studies and  
6 314 expertise recommendations, as such other variables that potentially affect UCC crowding might have been missed.  
7 315 During our study period, the process of triaging a low acuity (ESI levels 4 and 5) ED patient to UCC when the ED is  
8 316 determined to be severely overcrowded was not yet initiated. Therefore, the number of patients transferred from ED  
9 317 to UCC was not considered a risk factor impacting UCC crowding. Furthermore, consideration of average LOS and  
10 318 numbers of LWBS patients as the only patient care outcome measurements may not be enough to determine the  
11 319 most accurate association to UCC crowding. Other patient care outcome variables such as 72h UCC/ED returns,  
12 320 patient satisfaction, and nosocomial accidents which will be included in our ongoing multi-center validation study.

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17 322 **Conclusion**

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19 323 An overcrowding estimation tool (SONET) might be used to determine relative crowding status in a high volume  
20 324 UCC setting was derived in this study. The study also showed that UCC overcrowding might be associated with  
21 325 negative patient care outcomes.

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25 327 **Competing Interests:** N/A

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30 329 **Author contributions:** HW and RDR conceived the study and developed the design in consultation with all of the  
31 330 authors. CDC<sup>1</sup>, VAG, and CDC<sup>2</sup> assembled the data set and collected the data. HW, RDR, EKG, CDS, RDJ, and  
32 331 NRZ conducted the statistical analyses and drafted the article, and all authors read and approved the final manuscript.  
33 332 HW takes responsibility for the paper as a whole. (1: CDC: Chad D. Cowden; 2: CDC: Christopher D. Cook)

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37 334 **Acknowledgement:** We would like to thank all the UCC attending physicians, APPs, nursing staff, and unit clerks  
38 335 participating in this study.

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41 33642  
43 337 **Table legend:**

44  
45 338 Table 1 shows the clinical and operational variables and index collected in the UCC overcrowding study. There  
46 339 were total 20 individual operational variables and 5 indexes collected based on the previous ED overcrowding study  
47 340 and expertise's opinions.

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49 341 Table 2 shows the general information of patients in this study

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51 342 Table 3 shows the average LOS of patients who registered at UCC under the different crowding statuses determined  
52 343 by the SONET.

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54 344 Table 4 shows the average time spend at different stages in patients who registered at UCC under the different  
55 345 crowding statuses determined by the SONET

56 346 Appendix table shows the average LOS of discharged patients who registered at UCC under the different crowding  
57 347 statuses determined by the SONET

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
<b>Title and abstract</b>	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found <b>Explanation: a) <u>Yes</u>. This is a prospective study and was reported in the abstract section. b) <u>Yes</u>. In abstract, clearly addressed what was done and in result section, the findings were also reported.</b>
<b>Introduction</b>		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported <b><u>Yes</u>, we address the scientific background and the rationale for this study.</b>
Objectives	3	State specific objectives, including any prespecified hypotheses <b><u>Yes</u>, in the end of the introduction section, we reported a specific urgent care center overcrowding estimation tool will be derived and study primary and secondary goals (hypotheses)</b>
<b>Methods</b>		
Study design	4	Present key elements of study design early in the paper <b><u>Yes</u>, study design was reported in Line 70.</b>
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection <b><u>Yes</u>, location: Line 71-72, periods of recruitment: Line 87, exposure, follow-up: Line 78-84, this study did not require follow-up. Data collection: Line 111-154.</b>
Participants	6	<i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <b><u>Yes</u>, Line 78-84, this study did not require follow up.</b>
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable <b><u>Yes</u>, see section Variables: Line 111-138 and table 1.</b>
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 <b><u>Yes</u>, see section Variables: Line 111-138 and table 1.</b>
Bias	9	Describe any efforts to address potential sources of bias <b><u>Yes</u>, single center study with population selection bias will be inevitably occurred and this is addressed in our limitation section.</b>
Study size	10	Explain how the study size was arrived at <b><u>Yes</u>, line 73-75.</b>
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why <b><u>Yes</u>, three groups were divided in this study (N: not overcrowding; O: overcrowding; and S: severely overcrowding groups) and outcome measurements were compared with these three groups. See Line 145-154. How quantitative variables were handled</b>

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*in the analyses were also addressed in the statistics section* See Line 166-171.

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Statistical methods	12	<i>(a) Describe all statistical methods, including those used to control for confounding</i>
		<i>(b) Describe any methods used to examine subgroups and interactions</i>
		<i>(c) Explain how missing data were addressed</i>
		<i>(d) Cohort study—If applicable, explain how loss to follow-up was addressed</i>
		<i><u>Yes</u>, a): statistical methods addressed in detail in Line 155-172. b): see Line 166-170.</i>
		<i>c) see line 78-84. d) this study did not require any follow-up.</i>
		<i>(e) Describe any sensitivity analyses</i>

*N/A: no sensitivity analyses addressed in this study since there is no standard or previous similar study reported. However, consider the perceptions of overcrowding of healthcare providers as a “gold standard”, inter-rater reliability between the SONET scores and provider perceptions was measured. Line 197-200*

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Continued on next page

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60**Results**

Participants	13*	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. <i>Yes, see line 202-205. Table 2</i>
		Give reasons for non-participation at each stage <i>Yes, see line 202-203</i>
		Consider use of a flow diagram <i>No, since this is very easy to address in the manuscript, no flow diagram drawn.</i>
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders <i>Yes, see Table 2.</i>
		(b) Indicate number of participants with missing data for each variable of interest <i>Yes, see line 179-180, and 202-205.</i>
		(c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount) <i>No, this study did not require follow-up.</i>
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure
		<i>Cross-sectional study</i> —Report numbers of outcome events or summary measures <i>Yes, see result section: outcome measurements Line 201-244.</i>
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included <i>Yes, see Line 184-196. Results showed only 4 variables can be independent variables while others are the confounding factors.</i>
		(b) Report category boundaries when continuous variables were categorized <i>Yes, continuous variables are converted to categorical variables based on the results of previous study. See line 90-96.</i>
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period <i>N/A</i>
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses <i>Yes, see Table 4 and Appendix Table.</i>
<b>Discussion</b>		
Key results	18	Summarise key results with reference to study objectives <i>Yes, see Line 247-256.</i>
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 <i>Yes, see limitation section Line 302-317.</i>
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence <i>Yes, see discussion Line 257-300.</i>
Generalisability	21	Discuss the generalisability (external validity) of the study results <i>Yes, internal validation performed and no external validation reported in this study and also</i>

addressed in the limitation. see Line 200, 310-311.

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**Other information**

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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  
N/A

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

Appendix Table. The average LOS of discharged patients who registered at UCC under the different crowding statuses as determined by the SONET tool.

	Average LOS of Patients at UCC (min±SD, number of patients)					
	All patients	ESI-1	ESI-2	ESI-3	ESI-4	ESI-5
Not Overcrowded	133±76 (1445)	0	76±72 (35)	140±88 (335)	138±73 (952)	95±46 (120)
Overcrowded	169±79 (858) *p<0.001	0	78±61 (37) *p=1.000	172±93 (218) *p<0.001	179±72 (522) *p<0.001	138±53 (80) *p<0.001
Severely Overcrowded	196±87 (509) **p<0.001	0	69±55 (27) **p=1.000	188±99 (130) **p=0.327	211±75 (315) **p<0.001	189±83 (37) **p<0.001

Abbreviation: LOS: length of stay (time interval from initial patient registration to departure from UCC); UCC: urgent care center; SD: standard deviation; ESI: Emergency Severity Index. \*: comparison between not overcrowded and overcrowded groups; \*\*: comparison between overcrowded and severely overcrowded groups