An Audit of Critical Value Parameters at Two Regional Hospitals in Singapore

Dear Editor,

Dr George Lundberg first defined 'critical value' as one that represents a pathophysiological state at such variance with normal (expected values) as to be life-threatening, unless something is done promptly, and for which some corrective action could be taken.[1] Since then, there have been several reports of individual institutional or regional experiences with critical values.[2,3] Accurate and timely transmission of such values to the appropriate caregiver is one of the criteria that regulatory bodies worldwide require laboratories to meet for licensing and accreditation purposes.[4,5]

In this study, we conducted an audit of critical values encountered at Alexandra Hospital (AH; 400 beds) from January 2015 to June 2015, and Ng Teng Fong General Hospital (NTFGH; 700 beds) from July 2015 to July 2016 (the purpose of a longer study period at NTFGH being to appreciate transition to steady state). Both are public hospitals that offer the services of major medical and surgical specialties, are run by the same management (JurongHealth) and have similar departments of clinical chemistry, haematology, blood transfusion services, microbiology and anatomic pathology. Also, both hospitals share the same critical result list, workflow and protocol. The aim of our study was to compare and contrast the critical results data and use the information gathered to identify areas for improvement.

Critical results data were obtained from reports generated from our Laboratory Information System (LIS) and then exported to Microsoft Excel spreadsheets for further analysis. Statistical analysis was performed using the z-test of proportions.

Audit of Critical Values at AH from January to June 2015

Out of 430,719 results, 2096 (0.49%) were critical. The top 5 critical results were positive blood culture (14.5%), platelets (14%), serum potassium (K+, 13.5%), plasma glucose (9.1%) and serum sodium (Na+, 6.9%). Clinical chemistry had the most number of critical results (60.2%), followed by haematology (20.6%) and microbiology (17.9%). Comparing locations, the inpatient department had the highest proportion of critical results (68.9%), followed by the emergency department (ED; 24.6%) and outpatient (6.5%) department. The top 3 critical results within each location were: ED–plasma glucose (26.4%), serum K+ (20.9%) and lactate (10.7%); inpatient–positive blood culture (20.6%), platelets (16.7%) and serum K+ (10.5%); and outpatient – serum free thyroxine (fT4, 37.6%), plasma glucose (24.1%) and serum K+ (15.8%). The specialty with the greatest proportion of critical results was Medicine (55.3%), followed by ED (24.6%) and Intensive Care Unit (ICU; 10.3%). The 4 pm to 12 am period had the highest proportion of critical results (46%), followed by the 8 am to 4 pm period (30.6%) and 12 am to 8 am period (23.4%).

Audit of Critical Values at NTFGH from July 2015 to July 2016

Out of 1,868,752 results, 10,968 (0.59%) were critical. The top 5 critical results were positive blood culture (21.0%), platelets (12.0%), serum K+ (9.82%), serum Na+ (9.33%) and plasma glucose (8.42%). Clinical chemistry had the most number of critical results (52.5%), followed by microbiology (26.3%) and haematology (21.2%). Comparing locations, inpatient accounted for 72.1%, ED 24.8%, and outpatient 3.1%. The top 3 critical results within each location were: ED–plasma glucose (27.6%), serum K+ (17.3%) and haemoglobin (10.1%), inpatient–positive blood culture (28.5%), platelets (13.7%) and plasma glucose (11.6%) and outpatient–plasma glucose (13.5%), serum K+ (12.6%) and serum fT4 (11.7%). The specialty that had the most number of critical results was Medicine (52.6%), followed by ED (24.8%), then ICU (10.4%). The 4 pm to 12 am period had the highest number of critical results (48.5%), followed by the 8 am to 4 pm period (26.9%) and 12 am to 8 am period (24.6%).

Table 1 shows a summary of the comparison of critical results between AH and NTFGH.

We adopted the critical reportable result health care messaging system (CRR-HMS), an automated notification system (Fig. 1) which has an electronic audit trail, to help in performance monitoring and evaluation.

At AH, the time taken for a response to be recorded by CRR-HMS, or turnaround time (TAT), was between 11 to 30 minutes (48%), within 10 minutes (42%), between 31 to 60 minutes (9.3%) and beyond 60 minutes (0.7%). At NTFGH, TAT was between 11 to 30 minutes (55.8%), within 10 minutes (30%), between 31 to 60 minutes (13.2%)

Table 1. Comparison of Critical Results between AH and NTFGH

Parameter	AH January 2015 to June 2015 (n = 2096)	NTFGH July 2015 to July 2016 (n = 10, 968)	95% CI for Proportion Difference	*P* Value
Top 5 critical results, n (%)				
Positive blood culture	303 (14.5)	2298 (21.0)	(-0.082, -0.048)	<0.0001
Platelets	293 (14.0)	1311 (12.0)	(0.004, 0.037)	0.01
Serum potassium	283 (13.5)	1077 (9.8)	(0.021, 0.053)	<0.0001
Plasma glucose	191 (9.1)	923 (8.4)	(-0.007, 0.021)	0.32
Serum sodium	144 (6.9)	1023 (9.3)	(-0.037, -0.012)	0.0004
Laboratory section, n (%)				
Clinical chemistry	1296 (60.2)	5753 (53.0)	(0.071, 0.117)	<0.0001
Haematology	432 (20.6)	2335 (21.0)	(-0.026, 0.012)	0.50
Microbiology	376 (17.9)	2880 (26.0)	(-0.102, -0.065)	<0.0001
Hospital location, n (%)				
Inpatient	1444 (68.9)	7911 (72.1)	(-0.054, -0.011)	0.003
ED	516 (24.6)	2724 (24.8)	(-0.023, 0.018)	0.85
Outpatient	136 (6.5)	333 (3.0)	(0.023, 0.046)	<0.0001
Physician specialty, n (%)				
Medicine	1159 (55.3)	5769 (52.6)	(0.003, 0.051)	0.03
ED	516 (24.6)	2720 (24.8)	(-0.022, 0.019)	0.88
ICU	215 (10.3)	1140 (10.4)	(-0.016, 0.013)	0.88
Time period, n (%)				
8 am to 4 pm	642 (30.6)	2952 (26.9)	(0.015, 0.059)	0.0005
4 pm to 12 am	965 (46)	5314 (48.5)	(-0.048, -0.001)	0.05
12 am to 8 am	489 (23.4)	2702 (24.6)	(-0.033, 0.007)	0.21

AH: Alexandra Hospital; CI: Confidence interval; ED: Emergency Department; ICU: Intensive Care Unit; NTFGH: Ng Teng Fong General Hospital

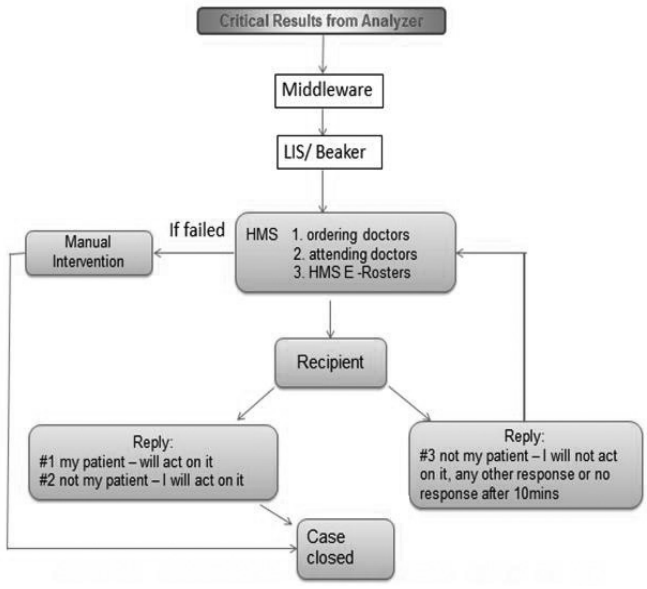

Fig. 1. Chart showing the critical result notification workflow.

and beyond 60 minutes (1%). The main reason for delayed notification (i.e. beyond 60 minutes) was delayed closure of the case by the call centre operator. Further investigations revealed no compromise in patient safety as appropriate management plans were already in place based on prior clinical suspicions.

Our audit shows that despite a larger patient population with an expected increase in workload at NTFGH, the proportion of critical results (0.59%) has remained comparable to that found by a College of American Pathologists (CAP) Q-Probes study of 121 institutions (less than 2%).[6]

Streamlining operational processes is crucial and one important component is the critical result list, which has considerable interlaboratory variation (Table 2). Making changes to this list can possibly reduce workload, and this should be done in discussion with the relevant clinicians and/or medical review board.[7] Doing a relevant literature review beforehand is beneficial as previously published lists from various studies[8,9] have advantages in terms of having undergone robust clinical evaluation. CAP has

Table 2. Comparison of Critical Result Limits at AH/NTFGH versus US* and UK†‡ Institutions

Test	AH/NTFGH	US	UK
Sodium (mmol/L)	<120 or >160	<120 or >158	<121 or >155
Potassium (mmol/L)	<2.5 or >6.0	<2.8 or >6.2	<2.7 or >6.2
Glucose (mmol/L)	<2.5 or >25.0	<2.6 or >26.9	<2.4 or >22.7
Platelet (x 10^9/L)	<50 or >1000	<37 or >910	<30 or >1000

AH: Alexandra Health; NTFGH: Ng Teng Fong General Hospital; UK: United Kingdom; US: United States

*Kost GJ. Critical limits for urgent clinician notification at US medical centers. JAMA 1990;263:704-7.

†Tillman J, Barth JH; ACB National Audit Group. A survey of 'laboratory critical (alert) limits' in the UK. Ann Clin Biochem 2003;40:181-4.

‡The Royal College of Pathologists (UK). Out-of-hours reporting of laboratory results requiring urgent clinical action to primary care: Advice to pathologists and those that work in laboratory medicine. Available at: https://www.rcpath.org/resourceLibrary/out-of-hours-reporting-of-laboratory-results-requiring-urgent-clinical-action-to-primary-care.html. Accessed on 29 April 2016.

also published a survey of critical result comparison of several clinical laboratories[10,11] which serves as a good reference. However, the selection of critical result values should be institution-specific and tailored to specific patient populations and their needs (e.g. a specialist haematology-oncology centre will have a very different white blood cell count critical result value compared to that in a polyclinic).

Another contributing factor is the notification process. There have been several studies[12,13] reporting the use of information technology to enhance the effectiveness of laboratory processes. To further improve on our TAT, we have sent out circulars to all stakeholders involved, such as call centre operators, reminding them of the need to close the case promptly. Automated alerts, such as red/green flags on-screen, can also serve as useful reminders. A repeat audit is planned in the near future to assess the impact of our improvement measures on TAT.

Personalising the notification process (e.g. building alerts that take into account not only the critical value, but also other information such as patient demographics, other related results and a change in current results from previous results) will possibly reduce the proportion of critical results and hence, laboratory workload. However, we have deliberated and found the risks of specialty/physician-specific lists to outweigh the benefits. For instance, the same patient may be admitted under different disciplines during different hospital admissions, and a specialty-specific list would only serve to complicate matters. Hence, we have decided not to adopt this personalised notification approach, mainly to safeguard patient safety.

In conclusion, this study has allowed us to understand our unique patient population characteristics better. Continued critical value audit and sharing of information with the relevant stakeholders are essential to maximising laboratory efficiency and maintaining patient welfare. Upholding such standards should be the joint effort of the laboratory, responsible healthcare professionals, information technology experts and all other relevant personnel involved.

The biggest challenge that remains is finding out how physicians actually deal with the critical results and the impact on patient management thereafter. We are planning to conduct an audit of such data in the near future, with hopes that the results will aid us further in tailoring laboratory processes to better meet the ever-changing needs of physicians and their patients.

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