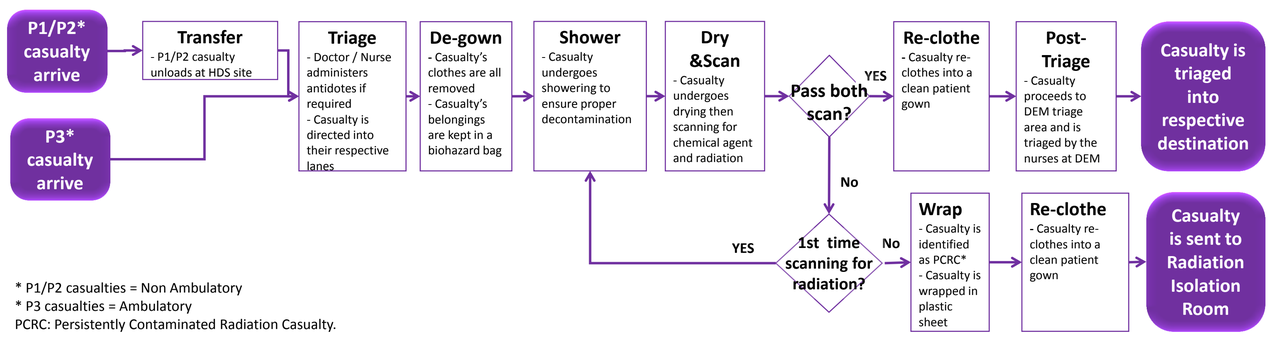
Using Simulation Modelling to Study the Performance of Hospital Decontamination Stations(HDS)

Chua Xin Ni, Kenneth Low Bing Hong, Wang Lei
Service Operations, Operations & Performance Management
Singapore General Hospital (SGH)

Singapore Healthcare Management 2016

Introduction

Hospital Decontamination Stations (HDS) are used to decontaminate casualties in the event of civil emergency involving hazardous material HAZMAT or Radiation Dispersal Device (RDD). The current HDS is situated outside SGH Accident and Emergency (A&E) building to ensure casualties are decontaminated before entering the A&E. Casualties are categorised into P1/P2 (non-ambulant) and P3 (ambulant).



* P1/P2 casualties = Non Ambulatory
* P3 casualties = Ambulatory
PCRC: Persistently Contaminated Radiation Casualty.

Figure 1: HDS Decontamination Workflow

The building of a new SGH A&E building provided the opportunity to expand and redesign the HDS. A simulation model was then employed to aid in the planning and decision-making.

Objectives

The project aims to study the impact on turn-around-time (TAT) of decontaminating casualties with changing parameters:

1) Configuration of HDS

2 different HDS configurations, were tested. Model 1 mimics the current single lane concept (Figure 2), while the Model 2 (Figure 3) clusters the showers, de-gown and scan areas, segregating the male and female into different lanes.

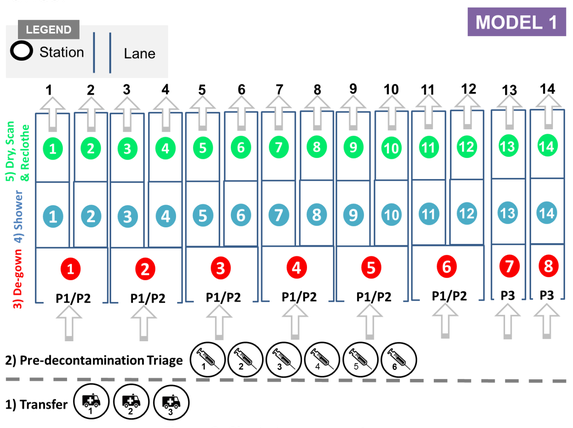


Figure 2: Single lane concept

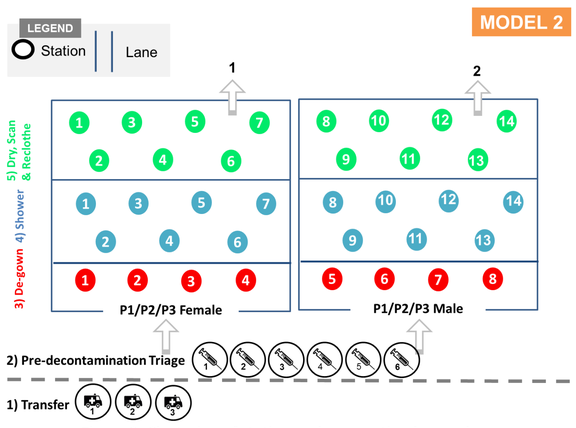


Figure 3: Clustering of station and segregation by gender

2) Number of HDS lanes & sections at these process step (Transfer, Pre-decontamination Triage, De-gown, Shower, Scan)

The second parameter was conducted by varying the number of HDS lanes and sections (Table 1) based on the selected model from the first parameter. The ratio of the number of stations at each section was derived based on the process time.

	Sections				
No. of lanes	**Transfer**	**Triage**	**Degown**	**Shower**	**Scan**
12 lanes	3 stations	6 stations	5 P1P2 stations 2 P3 stations	12 stations	12 stations
14 lanes	3 stations	6 stations	6 P1P2 stations 2 P3 stations	14 stations	14 stations
16 lanes	3 stations	6 stations	7 P1P2 stations 2 P3 stations	16 stations	16 stations

Table 1: Variations to the number of HDS

Methodology

Process times were collected during simulated dry-runs of HDS. Simulation models were developed using ARENA software to test the performance of the HDS based on the different parameters. 2 different arrival scenarios were tested out in the model (Table 2).

Arrival Scenario		i) Prepared On-Site (i.e. medical resources deployed on-site due to high security threat status)	ii) Unanticipated Incident
P1/P2 Arrival	Time of first arrival	H+30 minutes is based on an estimation of i.0 minutes for SCDF to arrive on site ii.10 minutes for SCDF to setup decontamination facilities iii.15 minutes to complete decontamination of first casualty iv.5 minutes to transport to hospital	H+45 minutes, based on an estimation of i.10 minutes for SCDF to arrive on site ii.15 minutes for SCDF to setup decontamination facilities iii.15 minutes to complete decontamination of first casualty iv.5 minutes to transport to hospital
	Rate of arrival	Average of 36 P1/P2 casualties per hour	Average of 36 P1/P2 casualties per hour
	Arrival Pattern	One P1 will arrive in one ambulance Two P2 will arrive in one ambulance	One P1 will arrive in one ambulance Two P2 will arrive in one ambulance
P3 Arrival	Time of first arrival	H + 2 hours	H + 10 minutes
	Rate of arrival	Average of 3 bus load of P3 casualties per hour	75% or 197 (263 x 75%) will arrive within the 1st hour from time of incident (Based on 1995 Tokyo Subway Sarin Gas Incident) Remaining 25% will arrive by the 3rd hour from time of incident
	Arrival Pattern	24 casualties per bus load.	Approximately 4 self-conveyed P3 casualties per minute will arrive based on calculation

Table 2: Arrival Scenario

The number of casualties requiring decontamination is based on Ministry of Health (MOH) planning norm in Year 2015, with 260 P1/P2 casualties and 263 P3 casualties. P1/P2 casualties have priority over P3 at any section due to their critical condition. It was also assumed that there will be equal number of male and female casualties.

In the event when a civil emergency is officially declared (H+0), the HDS will be set up within 20 minutes (H+20 minutes). However, between H+20 minutes to H+150 minutes, there will only be 1 triage, de-gown, shower and scanning operational, manned by First Respondent Team. Thereafter, after H+150 minutes, with the arrival of all HDS members, all lanes will be operational.

Results

b) Configuration of HDS

Both arrival scenarios shows that clustering of showers, de-gown and scan areas (Model 2) yielded better TAT than single lane concept (Model 1) as casualties are free to go into any available stations. Using prepared on site arrival scenario (i) as a reference (Figure 4), Model 1 has a median TAT of 1 hour and 4 minutes for P1/P2 casualties and 4 hours 20 minutes for P3 casualties. Model 2, on the other hand, has a median TAT of 50 minutes for the P1/P2 casualties and 3 hours and 32 minutes for the P3 casualties. Hence Model 2 has a 21.9% reduction in median TAT for P1/P2 and 18.5% reduction for P3 casualties.

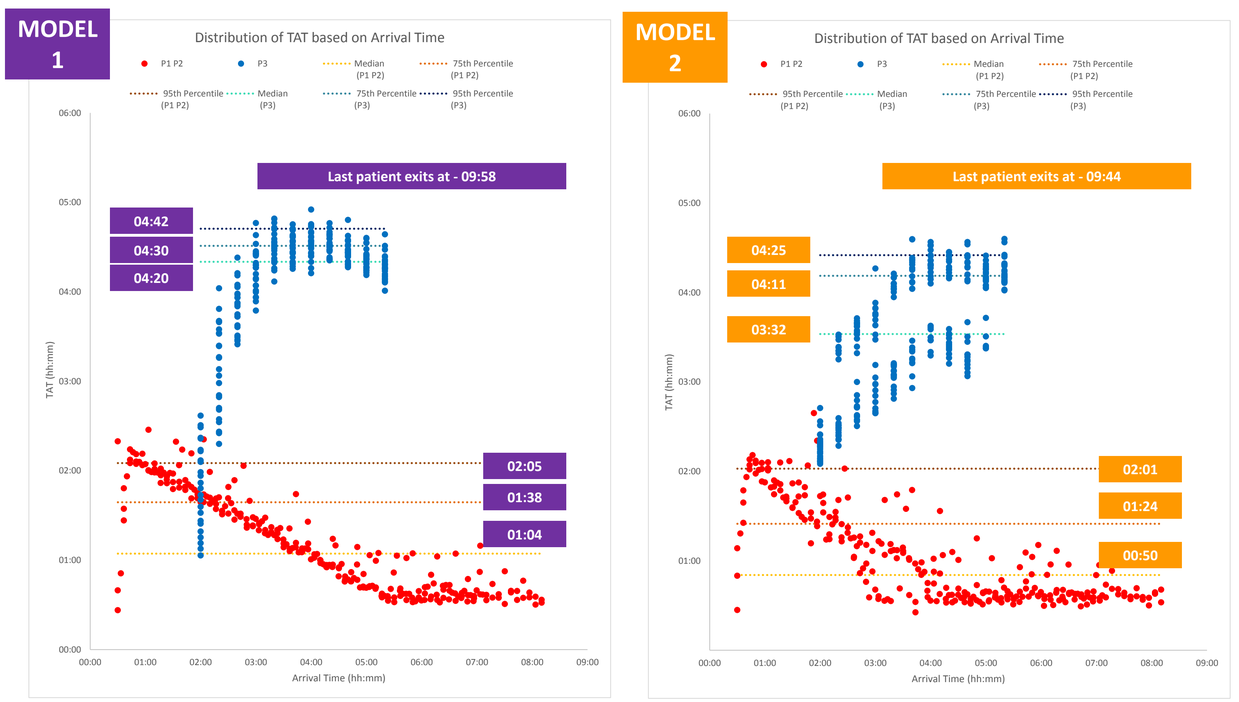


Figure 4: Distribution of TAT based on arrival time for Model 1 and Model 2

However, there were concerns of cross contamination due to splashing in Model 2 configuration. Weighing the reduction in TAT as compared to infection control measures, Model 1 was chosen as the preferred model.

b) Number of HDS

Using the prepared on site arrival scenario (i) as an example, a comparison was first made between 14 lanes and 16 lanes for single lane concept (Model 1) The model used an assumption of ad-hoc lane flexing (i.e. P3 casualties are allowed to use P1/P2 lanes whenever there is an available station). The results shows a 21.9% reduction in the P1/P2 median TAT.

A following comparison was then made between 12 lanes and 14 lanes. The assumptions of the model was modified to permanent flexing (i.e. P3 casualties are allowed to use P1/P2 lanes only at stipulated timing). The lanes were also further segregated into equal number of male and female lanes. Despite having more constraints, the reduction of median TAT was 28.7%. Taking into consideration the diminishing returns in TAT reductions for P1/P2 casualties, as well as manpower and space constraint, 14 lanes were recommended as the optimal choice.

c) Number of people waiting on platform

The main difference between the 2 arrival scenarios was the high influx of P3 casualties right at the start for unanticipated incident scenario (ii) which accounts for a much longer TAT for the P3 casualties. The maximum number casualties waiting could reach up to 30 P1/P2 and 248 P3 casualties in a 14 lanes facility (Figure 5), highlighting concerns of space and crowd control measures at the new HDS site.

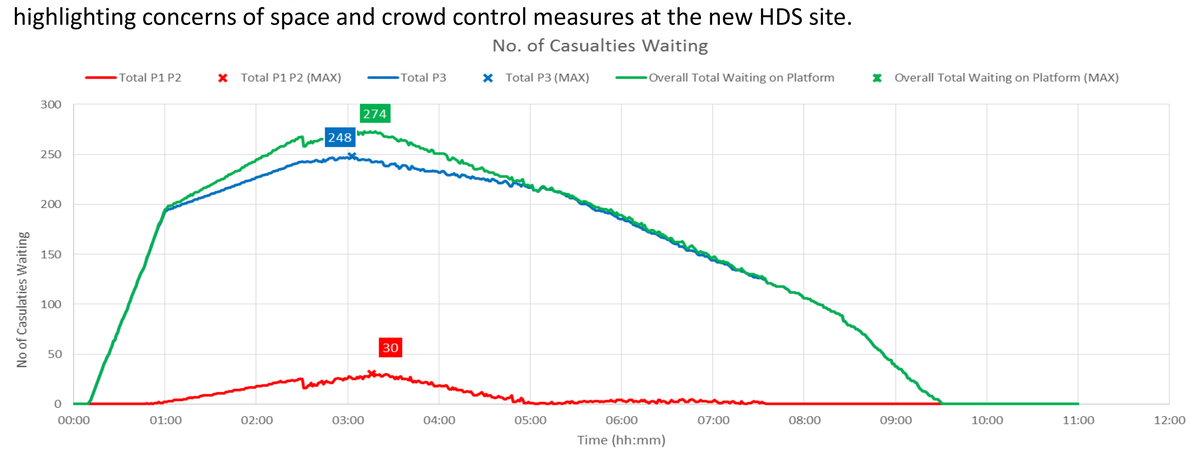


Figure 5: No. of casualties waiting for scenario (ii)

d) Utilisation of stations

The stations at de-gown, shower and scan are fully utilised as the model applies a pull system (i.e. casualty will occupy the de-gown station until there is a vacancy at shower station and casualty will occupy the shower station until there is a vacancy at scan station). However, results showed that in a 14 lane facility, the triage station utilization starts decrease to 4 stations at H+5 hours and 1 station H+7 hours. Hence manpower could be further deployed to other areas at these milestones.

Conclusion

Simulation modelling can provide insights into potential throughput, casualties' TAT and waiting time, utilisation of resources and number of people waiting, which will assist stakeholders in making well-informed decisions during facilities planning.

Aside from operational efficiency, infection control remains an important consideration. Hence, the choice of using Model 1 for further steps of optimisation.

Moving forward, there are plans to test the feasibility of employing these alternative workflows:

i. Scanning all SCDF-decontaminated casualties and only washing those that are still found to be contaminated
ii. Relocating P3 casualties, which has to be decontaminated, at a separate location offsite

Due to time constraints of the study, decontamination of staff operating HDS are not included in the model It is recommended that moving forward in the planning, decontamination of staff should be factored in to gain a more representative insight into the actual performance of the new HDS in SGH.