Implementation of A Structured Emergency Nursing Framework Results in Significant Cost Benefit

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Abstract

Background

Patients are at risk of deterioration on discharge from an emergency department (ED) to a ward, particularly in the first 72 hours. The implementation of a structured emergency nursing framework (HIRAID) in regional New South Wales (NSW), Australia, resulted in a 50% reduction of clinical deterioration related to emergency nursing care. To date the cost implications of this are unknown. The aim of this study was to determine any net financial benefits arising from the implementation of the HIRAID emergency nursing framework.

Methods

This retrospective cohort study was conducted between March 2018 and February 2019 across two hospitals in regional NSW, Australia. Costs associated with the implementation of HIRAID at the study sites were calculated using an estimate of initial HIRAID implementation costs (AUD) ($492,917) and ongoing HIRAID implementation costs ($134,077). Equivalent savings (i.e. in less patient deterioration) were calculated using projected estimates of ED admission and patient deterioration episodes via OLS regression with confidence intervals for incremental additional deterioration costs per episode used as the basis for scenario analysis.

Results

The HIRAID-equivalent savings exceed the costs of implementation under all scenarios (Conservative, Expected and Optimistic). The estimated preliminary savings to the study sites was $1,914,252 with a payback period of 75 days. Conservative projections estimated a net benefit of $1,813,760 per annum by 2022-23. The state-wide projected equivalent savings benefits of HIRAID equalled $227,585,008 per annum, by 2022-23.

Conclusions

The implementation of HIRAID reduced costs associated with resources consumed from patient deterioration episodes. The HIRAID-equivalent savings exceed the costs of implementation across a range of scenarios, and upscaling would result in significant patient and cost benefit.

Background

In-hospital adverse events are associated with increased mortality, morbidity and treatment costs[1] and the incidence of them in emergency admission patients is more than double that of non-emergency patient admissions[2]. Australia's 292 Emergency Departments (EDs) treated more than 8.2 million patients in 2019 – 20[3]. ED patients generally have undiagnosed conditions and varying degrees of clinical urgency and severity[4].

When patients attend an ED, emergency nurses are the first clinicians to assess the patient and commence emergency care, so patient safety is contingent on their accurate assessment, interpretation of clinical data, intervention, early recognition of deterioration and escalation of care[5,6]. Failure to recognise and respond to clinical deterioration during emergency care increases the incidence of high-mortality adverse events both during emergency care but also following the emergency care episode, irrespective of whether the patient is admitted to hospital or discharged[7,8].

Clinical deterioration within 72 hours of admission via the ED is an adverse event and can be associated with the care in ED[7,8]. Patients admitted via the ED and who deteriorate on the ward during the early stage of their admission also have significantly higher in-hospital mortality[7,9]. In our health district, the average (SD) treatment costs for patients who deteriorated within 72 hours of hospital admission via the ED were tripled, irrespective of diagnosis, age or hospital length of stay (LOS)[10].

Health care organisations outlay significant funds for nurse education, education staff and online mandatory training, yet evaluations that yield information about the return on investment are scarce, particularly in relation to patient safety or health service outcomes[11]. The existing evidence base does not enable any empirical conclusions to be drawn about the economic value of continuing health professional development[12]. This study seeks to examine the outcome of investment in an intervention with a considerable nursing education component in relation to cost benefit.

Implementation of a nurse-led framework called **HIRAID** (**H**istory, **I**dentify **R**ed flags, **A**ssessment, **I**nterventions, **D**iagnostics, communication and reassessment)[13] was developed for emergency care delivery (Fig. 1) in our Local Health District. The findings of this study resulted in a 50% (27–13%) reduction of inpatient clinical deterioration associated with care in the ED as classified by the Human Factors Classification Framework for patient safety[14]. HIRAID is the only validated framework designed to enable emergency nurses to systematically assess and manage ED patients[15]. The cost of HIRAID implementation and any cost-benefit is unknown. The aim of this study was to determine the financial costs and payback period of implementing the HIRAID emergency nursing framework and any potential future net financial benefits as a result of decreased inpatient deterioration related to ED care.

Methods

Study Design and Setting

This retrospective cohort study was conducted between March 2018 and February 2019 across two hospitals in regional NSW, Australia. This study was approved by the site health and medical human research ethics committee (LNR/16/WGONG/249) and conducted per the approved protocol.

Implementation of HIRAID

HIRAID was introduced to the EDs using a detailed implementation strategy reported elsewhere[16]. Modes of delivery selected to implement HIRAID included: (i) the development and compulsory completion of an eLearning module; (ii) attendance at a half day HIRAID workshop; (iii) integration of HIRAID into ED orientation programs and specialty training programs; (iv) mandated quarterly random audits of 10 episodes of initial nursing documentation at all sites; (v) introduction of cues within the workplace such as posters and reference cards; development and; (vi) mandated use of a documentation template based on the HIRAID assessment structure[16]. A template outlining the range of HIRAID implementation costs was generated. From this list of cost outlays, we determined the initial HIRAID implementation cost and ongoing annual implementation costs.

Cost of patient deterioration during early stages of emergency admission

Data on patients experiencing clinical deterioration (rapid response call, cardiac arrest, or unplanned intensive care unit admission) within 72 hours of admission were provided to the site costing unit. The AR-DRGs (v8.0) of these patients were extracted, and a cost comparison between those who did and did not have a deterioration episode was recorded. The top 10 AR-DRGs were also compared. Treatment costs included direct, indirect and corporate overhead costs. When controlled for confounders (LOS, AR-DRG code and others), the average incremental cost of clinical deterioration in the first 72 hours of hospital admission via the ED was $2,591.14 (CI +/- $654.92) [10] . These costs were used as the basis for the analyses in this study. The currency presented is Australian dollar (AUD).

Data analysis

Data were cleaned (validations and definitions) and collated for descriptive analysis. There were two main calculations within the analysis: i) hospital level net benefit figure; and ii) payback period. The hospital level net benefit figure was calculated by offsetting the cost of savings per episode of clinical deterioration within 72 hours of admission via the ED, against the initial and ongoing implementation costs per hospital from the HIRAID initiative. We used the confidence intervals from Curtis et al (2021) [10] as the basis for an *optimistic* ($2,591.14 + $654.92) and *conservative* case ($2,591.14 - $654.92) for the value of savings per episode of deterioration, with the *expected* case being $2,591.14 itself.

We then multiplied this value by the total expected patient deterioration in ED across NSW, estimated by taking the deterioration percentage (929 deterioration episodes/25,026 total ED admissions for our measured 352 common AR-DRG categories) in the HIRAID test sites[17]. This reflects a 3.7% deterioration proportion. That percentage was multiplied by the total projected ED admissions figure, initially obtained for 2018-19 using the NSW government health data portal[18], with 2% growth estimates conservatively estimated (the prior 7 years revealed an average growth rate higher than 2.5%). Multiplying these by the deterioration percentage gave us a deterioration estimate projection. The deterioration saving cost (conservative, expected and optimistic) were obtained by multiplying the relevant average cost of deterioration savings by the deterioration episode estimate, to reveal the state level projections. The hospital level savings projections were estimated by identifying a per hospital average of 465 deterioration encounters – obtained by dividing the 929 deterioration encounters noted in across both ED departments where the data were collected[17].

The payback period estimates how quickly the setup costs of an initiative, in this case, the implementation of HIRAID is “paid-back” or covered by the equivalent value of its benefits generated (reduction in deterioration). By dividing the implementation cost per annum by the equivalent savings estimate and multiplying the resulting number by 365 days, we generated a payback period – an assessment of how quickly the HIRAID investment “paid” for itself on an annual basis.

Results

The estimated initial HIRAID implementation cost in Year 1 was $492,917, and ongoing implementation costs $134,077 per annum (Table 1).

Table 1
HIRAID initial and ongoing implementation costs

	Initial outlay hours and line activity cost estimate								Ongoing outlay hours and line activity cost estimate						
Development and Production Activity	**Hrs CNC**	**Hrs NE**	**Hrs SS**	**Hrs RN3**	**Hrs HSM2**	**Hrs CNE**	**Cash outlay**	**Cost by line activity**	**Hrs CNC**	**Hrs NE**	**Hrs SS**	**Hrs RN3**	**Hrs HSM2**	**Hrs CNE**	**Cost by line activity**
eLearning module	40	4	16	4	4	4	0.00	$6,486	20	4	4	2	2		$2,713
Demo video for eLearning module	6	4	0	2	2	2	0	$1,154	6	4	0	2	2		$1,023
Revision of orientation manual	30	2	0	0	0	8	0	$3,117	30	2	0	0	0	8	$3,117
Curriculum development, train the trainers course. 58 senior staff over 8 days	260	64	0	512		24		$50,982	130	64	0	192		24	$50,982
RN 1hr training				220		24		$11,668				220		24	$11,668
Clinical champion nurse for each ED						896		$58,274						896	$58,274
Teaching manuals	8	8				8		$1,756	8	8				8	$1,756
Posters / Flipcards	2					8		$683	2					8	$683
Additional CNE time over implementation						564		$36,681							$ -
Promotional video	25							$2,042	25						$2,042
Documentation templates	2	1				1		$301	2	1				1	$301
Altering of policy	5							$408	5						$408
Audit tool	6							$490	6						$490
CNE, NUM time / meet	4	4						$618	4	4					$618
Evaluation							318255	$318,255							$ -
Total cost								$492,917							$134,077

CNC: Clinical nurse consultant, NE: Nurse educator, SS: Staff Specialist – Emergency Physician, RN: Registered Nurse, HSM: Health service manager, CNE: Clinical Nurse Educator

Of the 25,062 patients included in the study 929 patients experienced an episode of deterioration within 72 hours of admission via the ED (Table 2). Patients who deteriorated were significantly older (median 73.4 vs 67.5 years, $p < 0.001$) and had a longer median ED length of stay (9.0 vs 7.0 hours, $p < 0.001$), LOS (10.48 vs 8.99 days, $p < 0.001$) than patients who did not deteriorate. For patients who had an ICU admission, patients who deteriorated within 72 hours of admission via the ED had significantly longer ICU length of stay (3.74 vs 3.18 days, $p < 0.001$) than patients who did not deteriorate.

Table 2
Patient characteristics, emergency and hospital LOS by deterioration vs no deterioration event within 72 hours of admission via ED

Variable	No deterioration within 72 hours (n = 24,133)	Deterioration within 72 hours (n = 929)	p-value
Age – Median (IQR)	67.5 (44.9–80.9)	73.4 (60.8–83.0)	< 0.001
Gender – n (%)	11,518 (47.7)	474 (51.0)	0.048
Male	12,615 (52.3)	455 (49.0)	
Female			
ED LOS (h) – Median (IQR)	7.0 (3.9–12.3)	9.0 (5.4–14.4)	< 0.001
Site – n (%)	18,488 (76.6)	656 (70.6)	< 0.001
Site 1	5,645 (23.4)	273 (29.4)	
Site 2			
Time of presentation – n (%)	11,166 (46.3)	462 (49.7)	0.116
Morning (07:00–15:00)	8,876 (36.8)	319 (34.3)	
Afternoon (15:01–22:00)	4,091 (17.0)	148 (15.9)	
Night (22:01–06:59)			
Time of admission – n (%)	7,683 (31.8)	282 (30.4)	0.465
Morning (07:00–15:00)	9,611 (39.8)	368 (39.6)	
Afternoon (15:01–22:00)	6,839 (28.3)	279 (30.0)	
Night (22:01–06:59)			
Average ED LOS (hours)	8.99 (6.51)	10.48 (6.65)	< 0.001
Average hospital LOS (days)	4.54 (5.81)	12.47 (12.41)	< 0.001
Average ICU LOS (days)(ICU cases only)	3.18 (4.15)	3.74 (4.82)	< 0.001

Hospital net benefit

The hospital level net benefit figure in the first year of HIRAID implementation ranged from $1,305,831 (conservative) to $2,522,673 (optimistic) $2,371,555. The expected ongoing annual hospital net benefit figure was $2,472,610. This was calculated by multiplying the cost of savings per episode by the 465 average savings encounters per hospital (929 deterioration savings encounters/2 sites), and subtracting initial and ongoing implementation costs per hospital from this amount, as identified from HIRAID site estimates ($492,917 initial, ongoing $134,077 per annum). Staff research costs dominated initial year costings. These would be far less in new hospital sites, but we conservatively chose to include them. We showed net savings under all scenarios, across all five years, even when implementation cost concerns were considered (Table 3).

Table 3
Analysis of savings and net benefits from prevention of clinical deterioration in ward patients during the early stages of emergency admission

Outcome	2018–19	2019-20	2020-21	2021-22	2022-23
ED admission growth rate	3.34%	2.00%	2.00%	2.00%	2.00%
Projected ED admissions (352 AR-DRG)	2189030.929	2232811.547	2277467.778	2323017.134	2369477.477
Statewide deterioration episode projection	81143	82766	84421	86110	87832
Expected equivalent savings (state level estimates)					
Conservative ($1,936.22 per episode)	$157,110,699	$160,253,185	$163,457,629	$166,727,904	$170,062,075
Expected ($2,591.14 per episode)	$210,252,873	$214,458,293	$218,746,630	$223,123,065	$227,585,008
Optimistic ($3,246.06 per episode)	$263,395,047	$268,663,402	$274,035,631	$279,518,227	$285,107,942
Net benefit - hospital level estimates: expected equivalent savings less HIRAID implementation costs:					
Conservative ($1,936.22 per episode)	$1,798,748	$1,835,537	$1,872,325	$ 1,909,113	$ 1,947,837
Implementation costs (initial and ongoing)	-$492,917	-$134,077	-$ 134,077	-$ 134,077	-$ 134,077
Net savings	$ 1,305,831	$1,701,460	$1,738,248	$ 1,775,036	$ 1,813,760
*Payback period days: (Inv. Outlay/Det. Savings) * 365 days*	*100.02*	*26.66*	*26.14*	*25.63*	*25.12*
Expected ($2,591.14 per episode)	$2,407,169	$2,456,401	$2,505,632	$ 2,554,864	$ 2,606,687
Implementation costs (initial and ongoing)	-$492,917	-$134,077	-$134,077	-$134,077	-$ 134,077
Net savings	$1,914,252	$2,322,324	$2,371,555	$420,787	$2,472,610
*Payback period days: (Inv. Outlay/Det. Savings) * 365 days*	*74.74*	*19.92*	*19.53*	*19.15*	*18.77*
Optimistic ($3,246.06 per episode)	$3,015,590	$3,077,265	$3,138,940	$3,200,615	$3,265,536
Implementation costs (initial and ongoing)	-$492,917	-$134,077	-$134,077	-$134,077	-$134,077
Net savings	$2,522,673	$2,943,188	$ 3,004,863	$3,066,538	$3,131,459
*Payback period days: (Inv. Outlay/Det. Savings) * 365 days*	*59.66*	*15.90*	*15.59*	*15.29*	*14.99*

** Hospital deterioration episode encounter projection is 465, a whole number average per hospital deterioration from the 929 deteriorations observed over the two sites (*Table 1*).*

Hospital payback period

For return of investment for the initial implementation of HIRAID, the longest hospital payback period was 100 days (conservative scenario, 2018-19) and the quickest (shortest) payback period was 60 days (optimistic scenario, 2018-19). For ongoing investment and sustained implementation of HIRAID, the longest hospital payback period was 26 days (conservative scenario, 2018-19) and the quickest (shortest) payback period was 15 days (optimistic scenario, 2022-23). These are all well under a year, meaning the health service re-obtains their investment via the opportunity cost saving of deterioration avoidance.

NSW State-wide projected savings and payback period

State-wide HIRAID implementation projected savings were calculated at $227,585,008 per annum. The total projected ED admissions figure with 2% growth estimates conservatively estimated yielded the State-wide ED admissions shown in Table 3. The spectrum of cost savings possibilities presented statistically relates to 90% of possible outcomes (optimistic being in the top 5 percentile, conservative being in the bottom 5 percentile). For each scenario, the statistically derived equivalent savings per episode was multiplied against the number of deteriorations to calculate a savings figure.

Discussion

This study determined the initial investment required for and net financial benefits arising from the implementation of the HIRAID emergency nursing framework at a hospital and State-wide level. The implementation of HIRAID resulted in an estimated cost benefit of $1,914,252 to the study sites with a 75-day payback period. State-wide implementation of HIRAID could save NSW public hospitals $277 million per year as a result of decreased inpatient deterioration. These findings speak strongly in favour of the benefit of HIRAID economically, in addition to its clear patient level benefits.

The implementation of HIRAID required an initial investment, particularly to conduct education and training. This investment was rapidly offset in all three projected scenarios to 2022-23 All health professional education and introduction of interventions within ED come with significant costs, which we have explicitly described in this study. The importance of planning and investment in implementation cannot be understated. There are many instances of less than adequate implementation results in the ED setting where clinician behaviour change is difficult to achieve [19–22]. Successful implementation needs appropriate funding, planning and strategies that address the complexity and micro-politics embedded within all health care systems. Implementation strategies need to support individual practitioners, managers, and understand the context as well as receive strong organisational support and patronage which is influential to normalising a new practice among staff [23]. An evidence informed and context specific implementation strategy is essential to sustained, reliable and high uptake[16,24]. While education and training is accompanied by associated cost, this study has shown that HIRAID can lead to significant cost benefits and pay back for an organisation. We recommend the employment of a HIRAID nurse for 18 months to implement, embed and monitor uptake that is tailored for each ED context.

Prevention and early identification of patient deterioration improves outcomes, quality of life and lessens the intervention required to stabilise patients whose condition deteriorates unexpectedly in acute health service organisations[2]. Several health service wide interventions have been implemented to address the multiple complex organisational and workforce factors that contribute to patient deterioration[25]. Nonetheless, avoidable patient deterioration rates continue as a result of failure to recognise and rescue. Across the literature recognizing patient deterioration comprises four key areas: (1) assessing the patient; (2) knowing the patient; (3) education and (4) environmental factors[26]. The HIRAID framework[13], and accompanying implementation strategy[24] encompasses these areas ensuring emergency nursing staff have the capability, capacity and opportunity to apply HIRAID in their clinical practice.

Future research should include the evaluation of other benefits of improved emergency nursing care, nurse sensitive adverse events and patient deterioration. For example, the reduced LOS that is generated through reduced patient deterioration[14] and nurse sensitive adverse events[27] may create additional inpatient capacity. This in turn could improve associated key performance indicators such as non-compliance with emergency treatment performance (ETP), which is an independent predictor of all cause 30-day mortality for patients presenting to, and admitted via ED[28].

There are limitations to this study. Although all care was taken in the identification and assessment of patient deterioration events and a standardised process used, it is possible some were missed. This study was conducted in one health district, and despite the incidence of patient deterioration and adverse events in all hospitals, the types of incidences may differ, reducing the applicability to other hospitals. Cost estimates are likely to differ between countries, institutions and populations, thus potentially limiting the generalisability of this and all cost-effectiveness studies in health education[29].

Conclusions

The implementation of a structured emergency nursing framework resulted in substantial cost benefit with payback of investment within a year. The State-wide implementation of HIRAID could save $227 million per year. Initial investment in a dedicated senior implementation nurse is crucial for successful and sustained uptake.

Declarations

Ethics approval and consent to participate

This study was approved by the University of Wollongong's Human Research Ethics Committee (LNR/16/WGONG/249) and conducted per the approved protocol. All methods were performed in accordance with the NHMRC's National Statement on Ethical Conduct in Research Involving Humans. Due to the retrospective nature of this study, the informed consent was waived by the University of Wollongong's Human Research Ethics Committee.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the University of Wollongong HREC but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the University of Wollongong HREC.

Competing interests

The authors have no competing interests to declare.

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Authors' contributions

KC, PS and DB conceived and designed the study. All authors drafted the study protocol. KC, PS and DB supervised data collection and curation. PS & DB analysed the data. KC, PS, DB & JC interpreted the data. KC, PS and JC wrote the first draft of the manuscript, and all authors reviewed and approved the manuscript for submission.

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References

1. Harrison R, Walton M, Manias E, et al. The missing evidence: a systematic review of patients' experiences of adverse events in health care. *International Journal for Quality in Health Care.* 2015;27(6):424–442.
2. Australian Institute of Health and Welfare. Australia's health 2018: in brief. Cat. no. AUS 222. Canberra: AIHW. In. Canberra2018.
3. Australian Institute of Health and Welfare. Emergency Department Care 2019-20. Retrieved 11 March 2021 from https://www.aihw.gov.au/reports-data/myhospitals/sectors/emergency-department-care, Canberra. In:2021.
4. Fry M. Chapter 1: Emergency Nursing in Australia and New Zealand. In: Curtis K, Ramsden C, Shaban R, Fry M, Considine J, eds. *Emergency and Trauma Care: For Nurses and Paramedics*. 3rd ed. Chatswood NSW: Elsevier Australia; 2019.
5. Fasoli DR. The culture of nursing engagement: a historical perspective. *Nursing Administration Quarterly* 2010;34(1):18–29.
6. Considine J, Rhodes K, Jones D, Currey J. Systems for recognition and response to clinical deterioration in Victorian emergency departments. *Australasian Emergency Care.* 2018;21(1):3–7.
7. Considine J, Jones D, Pilcher D, Currey J. Patient physiological status during emergency care and rapid response team or cardiac arrest team activation during early hospital admission. *Eur J Emerg Med.* 2017;24 (5): 359–365.
8. Forster AJ, Rose NGW, Van Walraven C, Stiell I. Adverse events following an emergency department visit. *Quality and Safety in Health Care.* 2007;16(1):17–22.
9. Mora JC, Schneider AG, Robbins R, et al. Epidemiology of early Rapid Response Team activation after emergency department admission. *Australas Emerg Nurs J.* 2016;19(1):54–61.
10. Curtis K, Sivabalan P, Bedford D, et al. Treatments costs associated with inpatient clinical deterioration. Under review.
11. Maloney S, Haines T. Issues of cost-benefit and cost-effectiveness for simulation in health professions education. *Advances in Simulation.* 2016;1(1):13.
12. Brown CA, Belfield CR, Field SJ. Cost effectiveness of continuing professional development in health care: a critical review of the evidence. *BMJ.* 2002;324(7338):652–655.
13. Munroe B, Curtis K, Margerat M, Strachan L, Buckley T. HIRAID: An evidence-informed emergency nursing assessment framework. *Australasian Emergency Nurses Journal.* 2015;18(2):83–97.
14. Curtis K, Munroe B, Fry M, et al. The implementation of an emergency nursing framework (HIRAID) reduces patient deterioration: A multi-centre quasi-experimental study. *International emergency nursing.* 2021;56:100976.
15. Munroe B, Curtis K, Considine J, Buckley T. The Impact Structured Patient Assessment Frameworks Have on Patient Care: An Integrative Review. *Journal of Clinical Nursing.* 2013;22(21–22):2991–3005.
16. Curtis K, Munroe B, Van C, Elphick T-L. The implementation and usability of HIRAID, a structured approach to emergency nursing assessment. *Australasian Emergency Care.* 2020;23(1):62–70.
17. Mitchell RJ, Williamson A, Molesworth B. Application of a human factors classification framework for patient safety to identify precursor and contributing factors to adverse clinical incidents in hospital. *Appl Ergon.* 2016;52:185–195.
18. Bureau of Health Information. Reports - Health Care Quarterly, https://www.bhi.nsw.gov.au/BHI_reports#296580. 2021.
19. Scott PA, Meurer WJ, Frederiksen SM, et al. A multilevel intervention to increase community hospital use of alteplase for acute stroke (INSTINCT): a cluster-randomised controlled trial. *Lancet Neurol.* 2013;12(2):139–148.
20. Campbell JC, Coben JH, McLoughlin E, et al. An Evaluation of a System-change Training Model to Improve Emergency Department Response to Battered Women. *AEM.* 2001;8(2):131–138.
21. Dexheimer JW, Abramo TJ, Arnold DH, et al. Implementation and evaluation of an integrated computerized asthma management system in a pediatric emergency department: A randomized clinical trial. *Int J Med Inform.* 2014;83(11):805–813.
22. Middleton S, Dale S, Cheung NW, et al. Nurse-initiated acute stroke care in emergency departments. *Stroke.* 2019;50(6):1347–1355.

23. Rogers L, De Brún A, Birken SA, Davies C, McAuliffe E. The micropolitics of implementation; a qualitative study exploring the impact of power, authority, and influence when implementing change in healthcare teams. *BMC Health Serv Res.* 2020;20(1):1059.
24. Munroe B, Curtis K, Buckley T, Lewis M, Atkins L. Optimising implementation of a patient-assessment framework for emergency nurses: A mixed-method study. *Journal of clinical nursing.* 2018;27(1–2):269–286.
25. Australian Commission on Safety and Quality in Health Care. National consensus statement: essential elements for recognising and responding to acute physiological deterioration second edition. Sydney, ACSQHC.. In:2017.
26. Massey D, Chaboyer W, Anderson V. What factors influence ward nurses' recognition of and response to patient deterioration? An integrative review of the literature. *Nurs Open.* 2016;4(1):6–23.
27. Murphy A, Griffiths P, Duffield C, et al. Estimating the economic cost of nurse sensitive adverse events amongst patients in medical and surgical settings. *Journal of advanced nursing.* 2021;early online.
28. Dinh MM, Arce CP, Berendsen Russell S, Bein KJ. Predictors and in-hospital mortality associated with prolonged emergency department length of stay in New South Wales tertiary hospitals from 2017 to 2018. *Emergency Medicine Australasia.* 2020;32(4):611–617.
29. Tolsgaard MG, Tabor A, Madsen ME, et al. Linking quality of care and training costs: cost-effectiveness in health professions education. *Medical Education.* 2015;49(12):1263–1271.

Figures

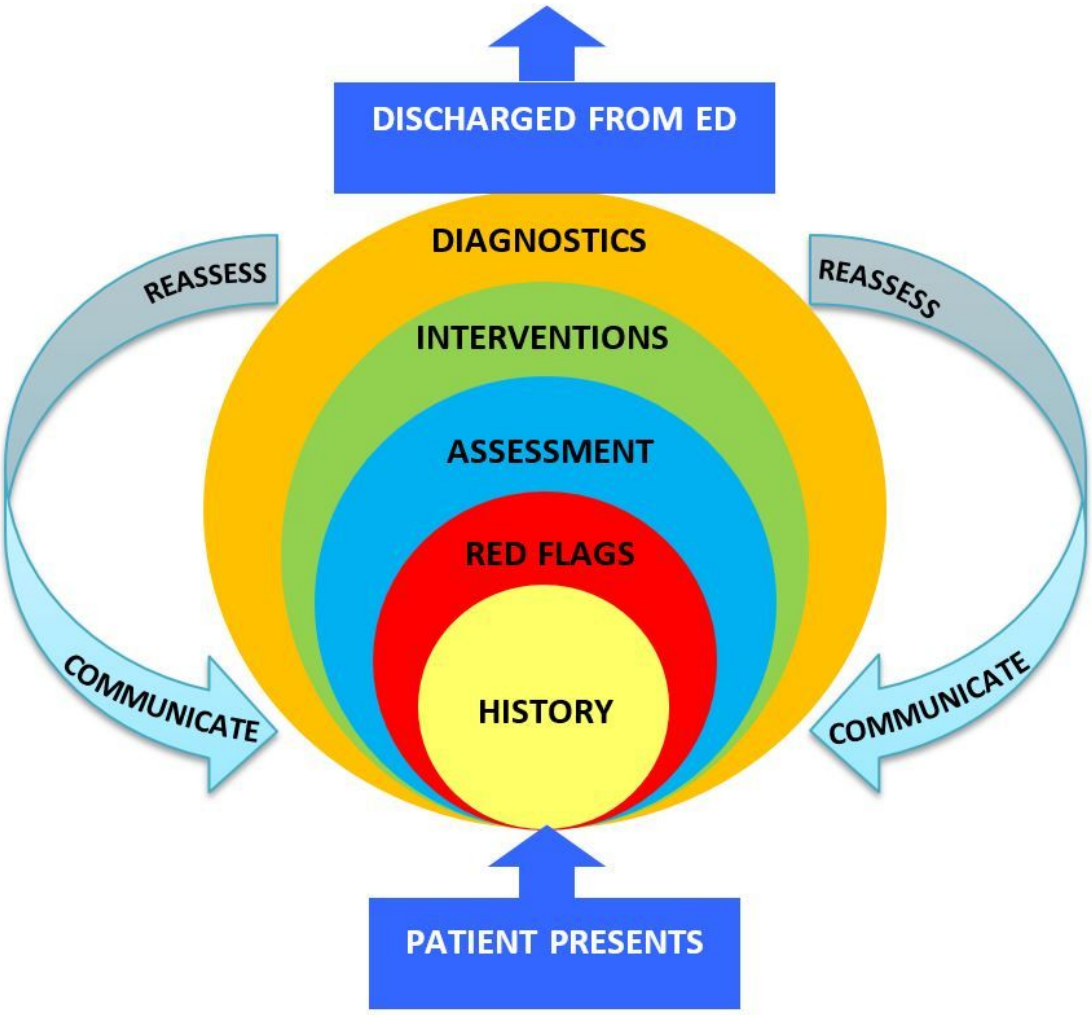

Figure 1

The HIRAID Emergency Nursing Framework © Curtis, Munroe, Murphy, Strachan, Lewis & Buckley 2016, adapted from Curtis et al, 2009