

A cost analysis of a 5-day simulation-based learning program for speech-language pathology student training

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3 1 **ABSTRACT**
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6 2 **Purpose:** There is poor reporting of the cost of simulation and greater transparency is
7
8 3 needed. The primary study aim was to conduct a financial analysis of the university/training
9
10 4 institution costs associated with a 5-day simulation-based learning program for speech-
11
12 5 language pathology students. The secondary aim was to consider the economic costs of the
13
14 6 model.

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18 7 **Method:** Costs associated with the delivery of a 5-day simulation-based learning program for
19
20 8 speech-language pathology students from six Australian universities were collected
21
22 9 regarding: (a) pre-program training, (b) personnel, (c) room hire, (d) equipment, and; (e)
23
24 10 consumables. Both financial costs and economic costs (Australian dollar, at June 2017) were
25
26 11 calculated per university site, and per student.

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28
29
30 12 **Result:** The simulation program was run 21 times involving 176 students. Average total
31
32 13 financial cost per program ranged from \$4,717 to \$11,425, with cost variation primarily
33
34 14 attributed to local labour costs and various use of in-kind support. Average financial cost per
35
36 15 student was \$859 (range \$683-\$1,087), however this was almost double (\$1,461 per student,
37
38 16 range \$857-\$2,019) in the economic cost calculation. Personnel was the largest contributing
39
40 17 cost component accounting for 76.6% of financial costs. Personnel was also the highest
41
42 18 contributing cost in the economic analysis, followed by room hire.

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46
47 19 **Conclusion:** This study provides clarity regarding financial and economic costing for a 5-day
48
49 20 simulation-based learning program. This data can help universities consider potential up-front
50
51 21 financial costs, and well as strategies for financial cost minimisation, when implementing
52
53 22 simulation-based learning within the University context.

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59 24 **Key words:** simulation, simulation-based learning, speech-language pathology, costs
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25 INTRODUCTION

26 Simulation is recognised as a valued teaching and learning method in health sciences
27 education (Harder, 2010). There has been increased inclusion of simulation within health
28 professional programs, in part due to the need to explore alternative clinical learning
29 experiences to lessen workforce demand in the context of rising student numbers. Benefits of
30 simulation such as the opportunity to practice skills in a safe learning environment, the
31 provision of targeted, equitable learning opportunities and the development of learner
32 confidence are well documented (Harder, 2010; Hewat et al., 2020; Hill et al., 2021). Despite
33 reported benefits, simulation also presents challenges, chief of which is the cost associated
34 with its implementation which varies depending upon factors such as level of technology use
35 and involvement of paid actors or faculty (Asche et al., 2017; Maloney & Haines, 2016).
36 Simulation can incur high costs, and these costs need to be evaluated to justify its inclusion as
37 a teaching and learning method when fiscal constraints on higher education funding prevail
38 (Zendejas et al., 2013). Unfortunately, in simulation research to date, costs are infrequently
39 and inconsistently reported (Asche et al., 2017; Foo et al., 2019; Hippe et al., 2020). Potential
40 barriers for reporting costs have been proposed in the literature, including poorly defined
41 justification for the need for cost data, lack of expertise conducting cost analyses, and the
42 complexity of undertaking cost analysis in the context of healthcare education (Walsh, 2013).
43 However, it is recognised that there is a need for transparency about the cost and value of
44 simulation (Hippe et al., 2020; Nestel et al., 2018; Zendejas et al., 2013) particularly given its
45 increased inclusion within health professional programs to supplement and/or replace
46 traditional workplace placements.

47 Despite reported barriers, some data related to the cost of simulation is available in
48 the health and medical education literature. Zendejas et al. (2013) applied Levin's framework
49 (Levin & McEwan, 2001) to complete a systematic review of technology-enhanced

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3 50 simulation costs. The most frequently reported cost within the reviewed literature related to
4
5 51 equipment and materials, with primary costs being simulation equipment purchase and
6
7
8 52 maintenance. More recently Hippe et al. (2020) conducted a systematic review of costs of
9
10 53 simulation in medical education more broadly and in neonatal resuscitation in particular. That
11
12 54 review yielded minimal studies, which were primarily focussed on small-scale
13
14
15 55 implementations which failed to consider long term and recurring costs associated with
16
17 56 maintenance of programs. The authors also reported a lack of transparency in the inclusion of
18
19 57 all relevant components of simulation development and implementation in costings, 'making
20
21 58 interpretation and comparisons challenging for stakeholders' (Hippe et al., 2020, p. 6).

24 59 While the body of evidence for the costs of simulation is limited, so too is the
25
26 60 understanding of how cost information is used in decision making about simulation
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28
29 61 education. A recent study reported a comparative analysis of the simulation costs of a 1-week
30
31 62 occupational therapy simulated clinical placement compared with a 1-week traditional
32
33 63 occupational therapy clinical placement (within typical workplace contexts)
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36 64 (Gospodarevskaya et al., 2019). In the 5-day model occupational therapy students engaged in
37
38 65 case studies and short case scenarios with standardised patients, supported by clinical
39
40 66 supervisors (Imms et al., 2018). The associated randomised controlled trial (RCT) showed
41
42 67 equivalent learning outcomes for students in both the simulated and traditional placements
43
44
45 68 (Imms et al., 2018), and the paper determined that costs within the simulated clinical
46
47 69 placement ranged from \$460 to \$1,511 per student with comparative costs for traditional
48
49
50 70 placements ranging from \$144 to \$1,112 per student (Gospodarevskaya et al., 2019). For both
51
52 71 simulated and traditional clinical placements, staff costs were predominant. Gospodarevskaya
53
54 72 and colleagues (2019) acknowledged that for those universities that pay for traditional
55
56 73 clinical placements, the simulated clinical placement option would be a cost-saving
57
58
59 74 alternative. However, despite this, and the evidence for equal learning outcomes, it was
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3 75 reported that the participant universities still favoured the traditional placement over the
4
5 76 simulated placement and were prepared to pay additional costs to implement such traditional
6
7 77 placements. Participating universities agreed that a future reduction in availability of
8
9 78 traditional placements may make the simulated placement option more attractive and viable.
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11
12 79 Such findings highlight that cost considerations are important, however, are only one factor
13
14
15 80 in decision-making around inclusion of simulation experiences in a degree program.
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18 81 Recently in speech-language pathology, a RCT demonstrated that a mean of 20% of
19
20 82 traditional clinical placement time could be replaced by a 5-day simulation-based learning
21
22 83 program with no loss to competency development (Hill et al., 2021). This finding supported
23
24 84 the role of simulation within speech-language pathology as not just a preparatory pedagogy,
25
26 85 but as a potential partial replacement for workplace learning opportunities which have
27
28 86 become increasingly scarce. Although the resources for the 5-day simulation-based learning
29
30 87 program are freely available, willingness and capacity of universities to implement the
31
32
33 88 program may be jeopardised by lack of knowledge of the cost of its implementation, and lack
34
35 89 of information on where/how any cost-saving measures may be applied without
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37
38 90 compromising outcomes. Previous research has identified either equipment (Zendejas et al.,
39
40 91 2013) or staffing (Gospodarevskaya et al., 2019) attract the highest cost in simulation
41
42
43 92 implementation. Within speech-language pathology simulation, a range of different modes
44
45 93 are employed for example, role-play, simulated patients and part-task trainers. However, the
46
47 94 most frequently reported mode of simulation is the inclusion of simulated patients (Dudding
48
49 95 & Nottingham, 2018) who are recognised as contributing a high-fidelity authentic learning
50
51 96 experience for students. Accordingly, it is important to investigate costs specifically
52
53
54 97 associated with speech-language pathology simulation experiences to obtain a realistic view.
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57 98 Within the RCT, the simulation-based learning program was implemented in the same
58
59 99 manner at each site (Hill et al., 2021) providing a unique opportunity to conduct a concurrent

1
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3 100 cost analysis without additional financial burden (Maloney et al., 2017). While it is
4
5 101 acknowledged that a cost-benefit analysis is necessary to enable a comprehensive exploration
6
7 102 of simulation as a teaching and learning model (Walsh et al., 2013), understanding the
8
9 103 financial costs of the program, and the key elements contributing to these costs, is the initial
10
11 104 step towards this goal. Hence, the primary aim of this study was to provide a detailed analysis
12
13 105 of the financial costs incurred by each site when implementing the 5-day simulation-based
14
15 106 learning program described by Hill et al. (2021). Financial cost information was considered
16
17 107 of principal interest in this study as it represents the out-of-pocket costs needed at each site to
18
19 108 implement the program. The secondary aim was to consider the economic costs of the model
20
21 109 to the University, where all costs have been fully considered.

26 110 **METHODS**

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28
29 111 This study involved the calculation of costs (by university site, and per student) associated
30
31 112 with running a 5-day simulation-based learning program for speech-language pathology
32
33 113 students recruited from six different Australian universities. Costs data was collected from
34
35 114 each participating university site across 28 of the total 29 simulation units trained within the
36
37 115 overall project (Hill et al., 2021). All university sites delivered the same 5-day simulation-
38
39 116 based learning program with multiple sets of students and gave approval for the collection of
40
41 117 costs data as part of broader ethical approval processes at each participating site for the
42
43 118 overall simulation evaluation project. However, individual student consent was not required
44
45 119 for the costs data collection. Hence, the numbers of student participants reported here
46
47 120 includes all who attended the simulation training, including those who consented to be part of
48
49 121 the simulation RCT study, and any non-consenting students (who completed the simulation
50
51 122 program but did not consent to be in the RCT).

57 123 ***Simulation-based Learning Program***

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3 124 All material resources (i.e., not human resources of staff and simulated patients) for the 5-day
4
5 125 simulation-based learning program are freely available at
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7
8 126 [https://www.speechpathologyaustralia.org.au/SPAweb/Resources_For_Speech_Pathologists/
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48 144 <a href=\\\\\\\\\)\\\\\\\\]\\\\\\\\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-
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40 140 <a href=\\\\\\\)\\\\\\]\\\\\\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-
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36 138 <a href=\\\\\\)\\\\\]\\\\\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-
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32 136 <a href=\\\\\)\\\\]\\\\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-
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28 135 <a href=\\\\)\\\]\\\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-
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24 133 <a href=\\\)\\]\\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-
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20 131 <a href=\\)\]\(https://www.speechpathologyaustralia.org.au/SPAweb/Resources_for_Speech_Pathologists/Simulation-
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16 129 <a href=\)](https://www.speechpathologyaustralia.org.au/SPAweb/Resources_For_Speech_Pathologists/Clinical_Education/Simulation-based_Learning_Program/SPAweb/Resources_for_Speech_Pathologists/Simulation-based_Learning_Program/Simulation-based_Learning_Program.aspx?hkey=c76641bc-4318-431a-9f5e-a870af826a5a)

The primary outcomes of the RCT have been previously published (Hill et al., 2021), and the framework used to develop the simulation-based learning program is reported in Hewat et al. (2020). However, in brief, six participating universities ran the same 5-day simulation-based learning program with their students. Across the 5-day program, speech-language pathology students participated in 13 different case-based simulations involving different aspects of swallowing and communication management with adult clients (Hewat et al., 2020; Hill et al., 2021). All simulations were conducted within a simulated clinical environment. Ten of the 13 simulations involved simulated patients and seven simulations were conducted within a simulated hospital ward environment. At one site a simulation co-ordinator (a dedicated person responsible for managing the simulation spaces) also supported the delivery/administration of the simulation program. In each 5-day simulation-based learning program, students were allocated to a ‘simulation unit’ of six to eight students. A trained simulation clinical educator supported each simulation unit. Educators were speech-language pathologists with experience in both clinical education and simulation who had completed customised training prior to their involvement. In a single simulation program at each university site, there were between one and three simulation units, each with a simulation clinical educator.

147 ***Cost Data Collection***

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3 148 The following data were collected to inform the calculation of costs per site and per student:
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5 149 the number of simulation-based learning programs run; the numbers of simulation units per
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7 150 simulation-based learning program; and the total number of students completing the
8
9 151 simulation-based learning program for each of the six universities over the study period. The
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11 152 structure of the cost data collection processes was informed by work of Levin and McEwan
12
13 153 (2001) and other authors (Lin et al., 2018; Walsh & Jaye, 2013) who emphasise the
14
15 154 importance of ensuring the use of a comprehensive framework of costs. Iterative discussion
16
17 155 between each site, their clinical and education researchers, and the study's health economists
18
19 156 (SK, SK, JB) identified resources required to inform the cost analysis. Data collection
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21 157 instruments to track resource use were piloted initially among the research group, with
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23 158 feedback from each site before implementation. Each university site completed their local
24
25 159 costings information for each separate simulation-based learning program run at their
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27 160 university.

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33 161 Cost information was collated and entered into a custom designed Excel spreadsheet
34
35 162 for analysis across five domains (Table 1): (a) pre-program training costs, which included
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37 163 salary/staff costs for simulated patient training (for trainers and simulated patients) and
38
39 164 educator training (for trainers and simulation clinical educators) prior to their involvement in
40
41 165 the program, as well as production costs of written training resources; (b) personnel costs,
42
43 166 which included salary costs for simulated patients, simulation clinical educators, and
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45 167 coordinators required for the 5-day delivery of the simulation-based learning program, fully
46
47 168 costed at the appropriate professional level (with oncosts) for the duties required (i.e.
48
49 169 including preparation), consistent with minimum employment hours rules (e.g., if a simulated
50
51 170 patient was needed for only one hour, yet minimum employment rates dictated a simulated
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53 171 patient must be paid for a minimum of three hours, then three hours were costed); (c) room
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55 172 hire, which included daily rental costs for space in dedicated simulation learning spaces
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3 173 and/or costs for renting standard rooms within a university that were used for the program;
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5 174 (d) equipment costs, which involved allocation of costs associated with the use of
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7 175 furniture/equipment (e.g., beds, bedside tables, drip poles) and materials to facilitate student
8
9 176 learning (e.g., patient files and iPads with apps) and enhance fidelity (e.g., clinical posters),
10
11 177 and; (e) consumables, which included therapy and assessment resources for swallowing and
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13 178 communication assessments, as well as student workbooks. All sites reviewed each
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15 179 completed cost report with a member of the study team (EC) to ensure all items had been
16
17 180 fully and appropriately reported.
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21

22 181 [Insert Table 1 near here]
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24

25 182 The financial costs for any service/staff/item were collected for all simulation-based learning
26
27 183 programs. For anything that was provided free of charge/in-kind by the participating
28
29 184 university (e.g., university staff providing role as a simulation clinical educator, or rental of a
30
31 185 university simulation lab provided at no cost for the project), a notation was made about this,
32
33 186 and an estimated cost (the cost that would have been paid had this been required) for that
34
35 187 item was also collected for use later in the economic cost analysis. All costs were reported
36
37 188 using the costing of the 2017 Australian dollar (reference for other currency conversion
38
39 189 \$1AUD = 0.7693 USD in June 2017) when the project commenced. The health economists
40
41 190 on the project team (SK, SK, JB) used this data to generate the financial and economic
42
43 191 analyses from a University/training provider perspective as follows.
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48 192 ***Cost analysis – Financial Costs*** 49

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51 193 The itemised costs for the five cost domains of each simulation-based learning program were
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53 194 first estimated, and averaged, to provide a total financial cost of implementing the simulation-
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55 195 based learning program at each university site. The financial cost analysis includes only the
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57 196 costs incurred during the trial (i.e. costs actually incurred and paid for), which included the
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3 197 costs paid for all items and assuming no carry-forward value of the items (purchased but not
4
5 198 used) and accepting that some costs were provided in-kind (without assuming an opportunity
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7 199 cost). This financial cost data was used to calculate costs per student using actual numbers of
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9 200 attending students per simulation-based learning program.
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201 *Cost analysis – Economic Cost*

202 A secondary analysis was conducted to determine the full economic costs of running the
203 simulation-based learning program. The economic cost analysis includes an estimated value
204 for 100% of all resources associated with delivering the simulation-based learning program
205 (i.e., accounting for opportunity costs). This secondary analysis also involved adjusting the
206 cost of durable goods (i.e., those items with a useful life greater than that of the trial period)
207 to more accurately estimate the per student cost. To estimate the cost per student for the
208 economic data, it was necessary to divide the fixed costs by the total number of students
209 educated per year. For durable items, assumptions were made regarding their useful life years
210 (Table 1) consistent with Australian Taxation Office (Australian Taxation Office, 2017) and
211 assuming constant decline in value over the useful life of the property. Assumptions were
212 made where necessary regarding the number of students to be educated each year over the
213 useful life of these items. Assumptions were also made regarding the number of simulation-
214 based learning programs conducted per year, the number of simulation units per simulation
215 program, and the total number of students in a simulation unit for each university which
216 would be constant over time, as outlined in Table 2.

217 [Insert Table 2 near here]

218 **RESULTS**

219 The demographic characteristics of the simulation-based learning programs conducted during
220 the study are presented in Table 3. Overall, across the six universities the 5-day simulation-

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3 221 based learning program was run 21 times (range 1-8), with between 1-3 simulation units
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5 222 attending the program at any one time (data from 28 simulation units included in cost
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7 223 analysis). The average number of students per simulation unit was 6.3, with a range of 5.7-8
8
9 224 across the universities. Overall, 176 students completed the simulation-based learning
10
11 225 program.

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15 226 [Insert Table 3 near here]

16 17 18 227 **Costs per university**

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20
21 228 The averaged total financial cost per simulation-based learning program across the six
22
23 229 universities was \$8,077. However, exploring the financial costs by each university revealed
24
25 230 the average ranged widely from \$4,717 to \$11,425 (Table 4), depending on local labour/staff
26
27 231 costs and various uses of in-kind support. For example, five of the six sites did not have
28
29 232 financial costs for simulation room hire as the facilities were locally available for staff, with
30
31 233 only one site, University 2, having to pay \$1,250 per simulation-based learning program
32
33 234 (altogether costing \$10,000 to run the simulation-based learning program eight times with 11
34
35 235 simulation units). Full breakdown of costs per university can be found in Supplementary
36
37 236 Table 1. In comparison, the calculated economic cost of the program was much higher, with
38
39 237 total economic cost per program, per site ranging from \$9,474 to \$16,152 (average =
40
41 238 \$12,860).

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46 239 [Insert Table 4 near here]

47 48 49 240 **Cost per student**

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52 241 Based on the financial cost analysis, the simulation-based learning program cost an average
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54 242 of \$859 per student (Table 5). Breakdown of the incurred costs per student, per university,
55
56 243 can be found in Supplementary Table 1. The majority of this cost (76.6%) was attributed to
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58 244 personnel involved in the delivery of the simulation-based learning program (simulated
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3 245 patients, simulation clinical educators etc). When the full economic costs were considered
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5 246 (i.e., after including an opportunity cost for services and items provided in-kind and
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7 247 apportioning the cost of durable items across their useful life), the simulation-based learning
8
9 248 program cost increased to an average of \$1,461 per student (Table 5). Personnel costs
10
11 249 remained the largest contributor to the economic costing (59.71%), with the cost of
12
13 250 simulation room hire the second largest cost driver (23.21%).
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18 251 [Insert Table 5 near here]
19

20 252 **DISCUSSION**

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23 253 The current analysis revealed the nature and extent of costs associated with a 5-day
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25 254 simulation-based learning program for speech-language pathology students. A strength of this
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27 255 research came from exploring the financial costs incurred from the program (i.e., the financial
28
29 256 cost analysis) across multiple deliveries of the program and across six university settings.
30
31 257 This financial cost data provides valuable insight into how financial costs vary in different
32
33 258 university/local contexts and how the costs of the model may be potentially mitigated through
34
35 259 different in-kind contributions. The secondary analysis then provided data on the full
36
37 260 economic costing of this model, which enables consideration of all costs of the model for an
38
39 261 institution when broader influences, such as opportunity costs for room hire and the costs
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41 262 across the lifetime of equipment etc, are considered.
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46 263 The 5-day simulation-based learning program studied in this research was designed to
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48 264 incorporate multiple case-based simulations within a simulated hospital environment,
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50 265 involved simulated patients, and provided support for student learning through a simulation
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52 266 clinical educator. The overall financial cost per simulation-based learning program averaged
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54 267 just over \$8,000, with the average financial cost per student being \$859. Due to the large
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56 268 variability in how simulation-based learning programs are developed for different learning
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3 269 experiences, it is difficult to compare these costs directly with other research. However, it is
4
5 270 noted that these costs were quite comparable to recent published data for a 1-week
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7
8 271 occupational therapy simulation placement which was also based within the Australian health
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10 272 context and used simulated patients across a number of case-based simulations. In that
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12 273 research, costs from a University perspective for their 5-day simulation-based learning
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14 274 program were reported to range between \$460 to \$1,511 per student (Gospodarevskaya et al.,
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16 275 2019).

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19
20 276 The simulation-based learning program was implemented as a replacement for five
21
22 277 days of traditional adult placement experience within a larger clinical placement (Hill et al.,
23
24 278 2021). The published RCT confirmed that the learning outcomes for students who completed
25
26 279 the simulation+traditional placement versus traditional only placements were equivalent (Hill
27
28 280 et al., 2021). However, in this study only the costs pertaining to the simulation-based learning
29
30 281 program component were calculated. As such, it is not possible to directly compare the costs
31
32 282 of the simulation+traditional program with the costs of a traditional only speech-language
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34 283 pathology student placement. At present there has been limited data reported on the costs
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36 284 associated with traditional clinical placements for either speech-language pathology or allied
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38 285 health student training in general (Gospodarevskaya et al. 2019; Maloney et al., 2017; Segal
39
40 286 et al., 2017). Consequently, the true costs of traditional clinical placement remain poorly
41
42 287 understood. Recent work within occupational therapy reported that the cost for five days of
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44 288 traditional placement ranged from \$144 to \$1,112 per student (Gospodarevskaya et al., 2019).
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46 289 If the occupational therapy data was used as proxy data for speech-language pathology
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48 290 placements, then it could be proposed that the costs associated with the current speech
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50 291 pathology simulation-based learning program are higher, though not too dissimilar, to
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52 292 traditional placement costs.
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3 293 It has long been understood that simulation can require significant financial
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5 294 investment (Lin et al., 2018; Nestel et al., 2018). However, more universities are needing to
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7 295 invest in simulation-based learning experiences as clinical placements come under increasing
8
9 296 pressure due to rising student numbers, and as additional pressures from global issues such as
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11 297 the recent COVID-19 pandemic exacerbate the challenges of providing traditional student
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13 298 placements. To this end the current data can provide speech pathology programs, and their
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15 299 universities, with a more accurate picture of both the immediate financial costs and the full
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17 300 economic costs involved. In particular the opportunity to examine how multiple different
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19 301 speech pathology departments implemented the program within this study provides valuable
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21 302 information on how costs can be managed depending on the use of in-kind resources. The
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23 303 data highlighted that key factors contributing to the costs of the simulation program include
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25 304 personnel and room hire. When these were covered by existing resources (e.g., academic staff
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27 305 taking on the role of a simulated patient, program coordinator or trainer), or where out-of-
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29 306 pocket costs can be waived (eg., simulation room hire fees), then the overall financial costs of
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31 307 the simulation-based learning program were reduced. It needs to be noted, however, that there
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33 308 were no program costs factored into the current cost analyses as the program is freely
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35 309 available. In other contexts (i.e. other simulation activities, other professional training), the
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37 310 cost of any chosen simulation program would be an additional cost to consider.
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45 311 Although the current data provides an indication of costs to deliver this specific
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47 312 program, it is recognised that the costs of simulation can also be reduced by considering the
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49 313 nature of the simulated learning experience offered to students. As highlighted in the current
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51 314 data, the use of simulated patients attracts a significant cost. It would be useful to determine if
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53 315 alternate or lower fidelity simulations, which have lower costs, could have the same desired
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55 316 learning outcomes for students. For example in a medical education study, Bosse et al. (2015)
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57 317 found better learning outcomes were achieved from using role play scenarios rather than
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3 318 standardised patients, and that role-play was more cost effective. Yet other medical research
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5 319 has reported different outcomes regarding role play, finding significantly improved
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8 320 performance for those students who engaged with simulated patients in comparison to
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10 321 students who participated in student role play only (Taylor et al., 2019). Hence, further
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12 322 research is needed to determine the relative benefits for student learning of the different
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14 323 simulation modalities in different contexts, and then the relative costs of such models. Such
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16 324 data will help develop future simulation models that achieve both the desired learning
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19 325 outcomes and are sustainable and cost-effective (Hippe et al., 2020).

22 326 As recommended by Lin et al (2018) and others, the current data uses a
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24 327 comprehensive data set, with an analysis by health economists (Lin et al., 2018; Foo et al.,
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26 328 2019), however there are limitations to acknowledge. The current data can only provide
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29 329 universities with insights into the financial and economic costs of this specific simulation-
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31 330 based learning program, and ways to minimise program costs, but not the overall cost benefit
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33 331 of the program. As the tertiary education dollar becomes tighter, full economic analysis of the
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35 332 cost benefits of simulation-based education are needed (Hippe et al., 2020). Furthermore, the
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37 333 concept of simulation-based learning “value” (Nestel et al., 2018) was not explored.
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40 334 Exploring “value” speaks to more than just considering the financial and economic costs and
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42 335 benefits based on resources, rather considers a wide range of tangible and intangible benefits
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44 336 arising from simulation-based learning such as student confidence, employer satisfaction and
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47 337 patient safety (Bukhari et al., 2017; Foo et al., 2017; Maloney & Haines, 2016; Nestel et al.,
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49 338 2018). Hence, future studies are needed that compare both costs and relative value to inform
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51 339 the adoption of simulation-based learning in speech-language pathology curricula.

54 340 Conclusion

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57 341 The current study provides detailed data on the nature and extent of the costs associated with
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59 342 the 5-day simulation-based learning component of a simulation+traditional placement for

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3 343 speech-language pathology students. This data was calculated from a large, robust data set
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5 344 and can be used with confidence by speech-language pathology educators to anticipate both
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7 345 the financial and economic costs associated with this type of 5-day simulation-based learning
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9 346 program. The use of a detailed framework for exploring all aspects of costs provides a
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11 347 comprehensive guide to enable settings to consider all costs associated with implementation.
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13 348 By identifying the areas of highest cost contribution, the current data can also assist training
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15 349 programs find ways to minimise costs within their own local contexts. Ongoing research is
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17 350 needed to identify methods of simulation training that achieve desired learning opportunities
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19 351 and minimise costs and, further examine the value and the cost effectiveness of simulation-
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21 352 based learning programs in student education.
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1 **Table 1:** Different types of cost and assumptions

Items	Type of cost	Assumed useful life (years)
Pre- program training		
Simulated patient training	Fixed	1
Simulated patient booking administration	Fixed	1
Simulated patient training workbooks	Fixed	1
Simulation clinical educators	Fixed	1
Simulation clinical educator training workbooks	Fixed	1
Training facilitators (those who conducted the training with the simulated patients and educators)	Fixed	1
Personnel		
Simulated patients	Fixed	1
Simulation clinical educators *adult clinician 5-15years experience with clinical education experience	Fixed	1
Simulation clinic facilitators	Fixed	1
Simulation coordinator - actual hours of work done (including prep before clinic commencement and during sim week)	Fixed	1
Room hire		
Breakout/debrief rooms	Fixed	1
Simulation labs	Fixed	1
Simulation rooms	Fixed	1
Simulation clinic/lab manager	Fixed	1
Equipment		
IV poles	Fixed	20
Hospital beds and bedside tables	Fixed	20
Hospital gowns	Fixed	5
Overbed tables	Fixed	5
Chairs for bedside and office simulations	Fixed	5
Table for the outpatient and the case handover simulation	Fixed	5
Laminated sign for behind hospital bed	Fixed	5
Water bottles	Fixed	5
Outpatient office table props - wire racks with manilla folders, textbooks, pens, tissues	Fixed	5
General clinic signs - handwashing, waiting room, professional posters e.g. thickened fluids/modified diets	Fixed	5
iPads	Fixed	5
Apps for iPads (Pocket brain, Neurosurgery conditions and treatments, cranial nerves pocket clinical resource, oxford concise medical dictionary, dysphagia, VLC media player) Up to clinic as to what apps to purchase. None mandatory.	Fixed	5
Therapy resources - laminated cards and A4 paper	Fixed	5
Patient files	Fixed	5
Optional props for nurse/dietitian - clipboard, lanyard, calculator (up to the clinic to increase authenticity)	Fixed	5
Consumables		
Thickened fluids	Variable	N/A
Food i.e. pureed apple, marshmallows, diced fruit, biscuits	Variable	N/A

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Tissues/cups/tongue depressors/spoons	Variable	N/A
Gloves	Variable	N/A
Patient ID wristbands	Variable	N/A
Hand sanitiser	Variable	N/A
Student workbooks	Variable	N/A
Anything additional	Variable	N/A

2 Note: N/A = not applicable

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3 **Table 2:** Institution specific assumptions regarding number of simulation-based learning
 4 programs, number of simulation units and number of total students as used in the economic
 5 analysis.

Institutions	Assumption 1 (number of simulation-based learning programs per year)	Assumption 2 (number of simulation units per simulation-based learning program)	Assumption 3 (total number of students per simulation unit)
1	3	2	7
2	7	2	7
3	2	2	6
4	7	1	6
5	1	2	7
6	1	1	8

9 **Table 3:** Participant enrolments in the simulation-based learning programs across the participating universities

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Simulation-based learning programs/students	University						All universities
	1	2	3	4	5	6	
No. of simulation-based learning programs run	3	8	2	6	1	1	21
No. of simulation units trained	5	11	3	6	2	1	28
Average no. of simulation units per simulation-based learning program	1.7	1.4	1.5	1.0	2.0	1.0	1.3
Average no. of students per simulation unit	6.6	6.3	6.0	5.7	7.0	8.0	6.3
Total no. of students attending simulation-based learning program	33	69	18	34	14	8	176

Table 4: Total costs per university site associated with running simulation-based learning programs

Site	No. of programs	Pre-program training	Personnel	Room hire	Equipment	Consumables	Total cost (all programs)	Average total cost per program*
1	3	\$4,882	\$19,244	\$0	\$2,162	\$168	\$26,456	\$8,819
2	8	\$3,547	\$50,780	\$10,000	\$1,539	\$148	\$66,014	\$8,252
3	2	\$4,683	\$13,295	\$0	\$1,541	\$51	\$19,570	\$9,785
4	6	\$1,945	\$25,460	\$0	\$780	\$117	\$28,302	\$4,717
5	1	\$3,249	\$8,134	\$0	\$0	\$42	\$11,425	\$11,425
6	1	\$804	\$4,631	\$0	\$0	\$27	\$5,462	\$5,462

*Determined by total cost divided by number of simulation-based learning programs conducted

12 **Table 5:** Financial and economic costs of the simulation-based learning program – per
 13 student.

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Site	Pre-program training	Personnel	Room hire	Equipment	Consumables	Total cost	Cost per student per day
<u>Financial cost per student</u>							
1	\$148	\$583	\$0	\$66	\$5	\$802	\$160
2	\$51	\$736	\$145	\$22	\$2	\$957	\$191
3	\$260	\$739	\$0	\$86	\$3	\$1,087	\$217
4	\$56	\$727	\$0	\$22	\$3	\$809	\$162
5	\$232	\$581	\$0	\$0	\$3	\$816	\$163
6	\$101	\$579	\$0	\$0	\$3	\$683	\$137
Ave	\$141	\$658	\$24	\$33	\$3	\$859	-
(% of costing)	(16.4%)	(76.6%)	(2.8%)	(3.8%)	(0.3%)	(100%)	
<u>Economic cost per student</u>							
1	\$189	\$454	\$164	\$29	\$21	\$857	\$171
2	\$88	\$1,069	\$139	\$4	\$8	\$1,308	\$262
3	\$278	\$775	\$500	\$13	\$18	\$1,584	\$317
4	\$168	\$1,387	\$333	\$4	\$21	\$1,914	\$383
5	\$344	\$642	\$63	\$19	\$14	\$1,082	\$216
6	\$256	\$906	\$836	\$3	\$18	\$2,019	\$404
Ave	\$221	\$872	\$339	\$12	\$17	\$1,461	-
(% of costing)	(15.1%)	(59.7%)	(23.2%)	(0.8%)	(1.2%)	(100%)	

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Supplementary Table 1. Breakdown of financial costs of simulation-based learning program, by university site, and per student

Cost Item	Cost per University Site (Cost per student)					
	1	2	3	4	5	6
Pre program training						
Simulated patient training	\$2,107 (\$64)	\$1,467 (\$21)	\$3,760 (\$209)	\$695 (\$20)	\$2,520 (\$180)	\$636 (\$80)
Simulated patients - refresher training only	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)
Simulated patients booking administration	\$504 (\$15)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$168 (\$21)
Simulated patient training workbooks	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)
Simulation clinical educators	\$2,271 (\$69)	\$2,080 (\$30)	\$923 (\$51)	\$1,250 (\$36)	\$729 (\$52)	\$0 (\$0)
Simulation clinical educator - refresher training	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)
Simulation clinical educator training workbooks	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)
Training facilitators (those who conducted the training with the simulated patients and program educators)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)	\$0 (\$0)
<i>Total pre-program training cost</i>	\$4,882 (\$148)	\$3,547 (\$51)	\$4,683 (\$260)	\$1,945 (\$56)	\$3,249 (\$232)	\$804 (\$101)
Personnel						
Simulated patients	\$6,542 (\$198)	\$15,407 (\$223)	\$5,180 (\$228)	\$6,996 (\$200)	\$3,510 (\$251)	\$2,108 (\$264)
Simulation clinical educators	\$12,702 (\$385)	\$35,373 (\$513)	\$8,115 (\$451)	\$15,200 (\$434)	\$4,624 (\$330)	\$2,523 (\$315)
Simulation clinic facilitators	\$0	\$0	\$0	\$0	\$0	\$0

	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$3,264	\$0	\$0
Simulation coordinator - (including prep and during sim)	(\$0)	(\$0)	(\$0)	(\$93)	(\$0)	(\$0)
<i>Total personnel cost</i>	<i>\$19,244</i>	<i>\$50,780</i>	<i>\$13,295</i>	<i>\$25,460</i>	<i>\$8,134</i>	<i>\$4,631</i>
	(\$583)	(\$736)	(\$739)	(\$727)	(\$581)	(\$579)
Room hire						
	\$0	\$10,000	\$0	\$0	\$0	\$0
Breakout/debrief rooms	(\$0)	(\$145)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Simulation labs	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Simulation rooms	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Simulation clinic/lab manager	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$10,000	\$0	\$0	\$0	\$0
<i>Total room hire cost</i>	<i>(\$0)</i>	<i>(\$145)</i>	<i>(\$0)</i>	<i>(\$0)</i>	<i>(\$0)</i>	<i>(\$0)</i>
Equipment						
	\$0	\$0	\$0	\$0	\$0	\$0
IV poles	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Hospital beds and bedside tables	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Hospital gowns	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Overbed tables	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Chairs for bedside and office simulations	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Table for the outpatient and the case handover simulation	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
	\$0	\$0	\$0	\$0	\$0	\$0
Laminated sign for behind hospital bed	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)

		(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
		\$15	\$30	\$30	\$15	\$0	\$0
6	Water bottles	(\$0)	(\$0)	(\$2)	(\$0)	(\$0)	(\$0)
		\$55	\$110	\$110	\$55	\$0	\$0
9	Outpatient office table props	(\$2)	(\$2)	(\$6)	(\$2)	(\$0)	(\$0)
		\$0	\$0	\$0	\$0	\$0	\$0
12	General clinic signs	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
		\$1,788	\$1,192	\$1,192	\$596	\$0	\$0
14	iPads	(\$54)	(\$17)	(\$66)	(\$17)	(\$0)	(\$0)
		\$132	\$88	\$88	\$44	\$0	\$0
16	Apps for iPads	(\$4)	(\$1)	(\$5)	(\$1)	(\$0)	(\$0)
		\$0	\$0	\$0	\$0	\$0	\$0
18	Therapy resources	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
		\$153	\$102	\$102	\$51	\$0	\$0
21	Patient files	(\$5)	(\$1)	(\$6)	(\$1)	(\$0)	(\$0)
		\$19	\$17	\$19	\$19	\$0	\$0
23	Optional props for nurse/dietitian	(\$1)	(\$0)	(\$1)	(\$1)	(\$0)	(\$0)
		\$2,162	\$1,539	\$1,541	\$780	\$0	\$0
26	<i>Total equipment cost</i>	(\$66)	(\$21)	(\$86)	(\$22)	(\$0)	(\$0)
27	Consumables						
		\$0	\$0	\$0	\$0	\$0	\$0
29	Thickened fluids	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
		\$43	\$99	\$27	\$54	\$18	\$9
31	Food	(\$1)	(\$1)	(\$2)	(\$2)	(\$1)	(\$1)
		\$34	\$49	\$24	\$33	\$24	\$18
33	Tissues/cups/tongue depressors/spoons	(\$1)	(\$1)	(\$1)	(\$1)	(\$2)	(\$2)
		\$42	\$0	\$0	\$0	\$0	\$0
36	Gloves	(\$1)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
		\$0	\$0	\$0	\$0	\$0	\$0
38	Patient ID wristbands						

	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
Hand sanitiser	\$49	\$0	\$0	\$0	\$0	\$0
	(\$1)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
Student workbooks	\$0	\$0	\$0	\$0	\$0	\$0
	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
Anything additional	\$0	\$0	\$0	\$30	\$0	\$0
	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)	(\$0)
<i>Total consumables cost</i>	\$168	\$148	\$51	\$117	\$42	\$27
	(\$4)	(\$2)	(\$3)	(\$4)	(\$3)	(\$3)
TOTAL COST	\$26,456	\$66,014	\$19,570	\$28,302	\$11,425	\$5,462
	(\$802)	(\$957)	(\$1,087)	(\$809)	(\$816)	(\$683)

Note: price per student based on shared use of each item (where applicable) and individual site usage

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For Peer Review Only