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ORIGINAL ARTICLE

Health economic burden that different wound types impose on the UK's National Health Service

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Abstract

The aim of this study was to estimate the patterns of care and annual levels of health care resource use attributable to the management of different wound types by the UK's National Health Service (NHS) in 2012/2013 and the annual costs incurred by the NHS in managing them. This was a retrospective cohort analysis of the records of 2000 patients in The Health Improvement Network (THIN) Database. Patients' characteristics, wound-related health outcomes and all health care resource use were quantified, and the total NHS cost of patient management was estimated at 2013/2014 prices. The NHS managed an estimated 2·2 million patients with a wound during 2012/2013. Patients were predominantly managed in the community by general practitioners (GPs) and nurses. The annual NHS cost varied between £1·94 billion for managing 731 000 leg ulcers and £89·6 million for managing 87 000 burns, and associated comorbidities. Sixty-one percent of all wounds were shown to heal in an average year. Resource use associated with managing the unhealed wounds was substantially greater than that of managing the healed wounds (e.g. 20% more practice nurse visits, 104% more community nurse visits). Consequently, the annual cost of managing wounds that healed in the study period was estimated to be £2·1 billion compared with £3·2 billion for the 39% of wounds that did not heal within the study year. Within the study period, the cost per healed wound ranged from £698 to £3998 per patient and that of an unhealed wound ranged from £1719 to £5976 per patient. Hence, the patient care cost of an unhealed wound was a mean 135% more than that of a healed wound. Real-world evidence highlights the substantial burden that wounds impose on the NHS in an average year. Clinical and economic benefits to both patients and the NHS could accrue from strategies that focus on (a) wound prevention, (b) accurate diagnosis and (c) improving wound-healing rates.

Introduction

We recently reported that the UK's National Health Service (NHS) managed an estimated 2·2 million patients with a wound during 2012/2013, equivalent to 4·5% of the adult population (1). The annual cost to the NHS attributable to wound management and associated comorbidities was estimated at £5·3 billion (1). This equated to 4% of total expenditure on public health in the UK in 2013 (i.e. £125·5 billion) (2). After adjustment for comorbidities, the annual NHS cost of managing wounds was estimated to be £4·5–5·1 billion, two-thirds of which was incurred in the community and the rest in secondary care (1). This is comparable with the annual NHS cost of managing obesity, which was estimated at £5·0 billion in 2013 (3).

Key Messages

- this study estimated the health outcomes, resource implications and associated costs attributable to managing different wound types in 2012/2013 using real-world

evidence obtained from the electronic records of 2000 patients in the THIN database (a nationally representative database of clinical practice among >11 million patients registered with general practitioners in the UK)
- the study showed that the NHS managed an estimated 2·2 million patients with a wound during 2012/2013; the annual NHS cost of managing these wounds and associated comorbidities was £5·3 billion; however, costs differed according to wound type, varying between £1·94 billion for managing 731 000 leg ulcers and £89·6 million for managing 87 000 burns
- an estimated 1·3 million wounds healed (61%) and 0·9 million remained unhealed (39%); resource use associated with managing the unhealed wounds was substantially greater than that of managing the healed wounds; consequently, the annual cost of managing the healed wounds in the study period was estimated to be £2·1 billion compared with £3·2 billion for the 39% of wounds that did not heal within the study year
- within the study period, the cost per healed wound ranged from £698 to £3998 per patient and that of an unhealed wound ranged from £1719 to £5976 per patient; hence, the cost of patient care for an unhealed wound was a mean 135% more than that of a healed wound
- real-world evidence highlights the substantial burden that wounds impose on the NHS in an average year; strategies that focus on (a) wound prevention, (b) accurate diagnosis and (c) improving wound-healing rates could generate clinical and economic benefits to both patients and the NHS

We have already reported the prevalence of each wound type (1). However, the aim of this article is to report the patterns of care and related resource use attributable to managing the different wound types in an average year and the annual costs incurred by the NHS in managing them.

Methods

Study design

This was a retrospective cohort analysis of the records of patients in The Health Improvement Network (THIN) database, as previously described (1).

Study population

The study population comprised the anonymised case records of a randomly selected cohort of 1000 patients from the THIN database who had a wound between 1 May 2012 and 30 April 2013 (cases) and a randomly selected cohort of 1000 control patients (controls) from the database, who were matched with the cases according to age, gender and the patient's general practice.

Inclusion criteria for the cases were:

- had to be aged 18 years or above
- had to have a Read code for a wound
- had to have continuous medical history in their case record, from the first mention of a wound in the study year up to the time the data were extracted from the database, unless they died, in order to exclude patients who had moved or changed their general practice

Exclusion criteria for the cases were:

- patients with a surgical wound if they healed within 4 weeks of the surgical procedure (as any resource use incurred will be because of the surgical procedure and not the wound)
- patients with a dermatological tumour

One thousand control patients were matched with 1000 cases according to the following criteria:

- age
- gender
- being managed at the same general practice
- no history of a wound in their medical record at any time
- had continuous medical history in their case record, from the matched start date up to the time the data were extracted from the database, unless they died

The authors obtained the complete medical records of the 2000 patients in the dataset, which enabled analysis of data within and outside of the study period.

Study variables and statistical analyses

Information was systematically extracted from the patients' records over the study period in accordance with the protocol. Wound type was documented in the patients' records, and the authors categorised them as being either acute (i.e. abscess, burn, open wound, unhealed surgical wound, trauma) or chronic (i.e. diabetic foot ulcer, arterial leg ulcer, mixed leg ulcer, venous leg ulcer, pressure ulcer).

Patients' characteristics, comorbidities (defined as a non-acute condition that patients were suffering from in the year before the start of their wound and not necessarily the year before the start of the study period), wound-related health outcomes and all community-based and secondary care resource use were extracted from the electronic records. All the data were quantified for cases and controls and stratified according to wound type. Differences between the groups were tested for statistical significance using either a Mann–Whitney U test or a χ^2 test.

Logistic regression was used to investigate relationships between baseline variables and clinical outcomes. Multiple linear regression was also used to assess the impact of patients' baseline variables on resource use and clinical outcomes. All statistical analyses were performed using IBM SPSS Statistics (V.22.0; IBM Corporation (IBM United Kingdom Limited, Portsmouth, Hampshire, UK)).

Health economic modelling

Using the THIN dataset, a computer-based model was constructed depicting the treatment pathways and associated management of the 1000 patients with a wound and the 1000

Table 1 Patients' baseline characteristics

Wound type	Mean age per patient	Percentage of male (%)	Percentage of smoker (%)	Percentage of ex-smoker (%)	Percentage of non-smoker (%)	Percentage with unknown smoking status (%)	Percentage of new wounds in the study period (%)	Percentage of wounds that healed in the study period (%)
Abscess	55·96	53	24	46	31	0	90	74
Burn	51·80	36	31	15	51	3	88	85
Diabetic foot ulcer	67·59	66	25	41	30	4	55	41
Leg ulcer (arterial)	79·00	25	25	50	25	0	40	0
Leg ulcer (mixed)	81·64	27	27	45	9	18	50	42
Leg ulcer (unspecified)	73·66	42	15	34	47	4	68	47
Leg ulcer (venous)	73·47	44	12	47	37	4	52	47
Open wound	70·71	44	10	46	42	2	88	71
Pressure ulcer	77·88	38	12	43	42	3	80	42
Surgical wound	64·90	50	24	33	42	1	88	74
Trauma	67·75	44	21	45	34	0	92	89
Unspecified	67·88	41	16	44	38	2	87	71

matched patients who had never had a wound. The model spans the 12-month period, from 1 May 2012 to 30 April 2013.

Unit costs at 2013/2014 prices (4–6) were applied to the resource use in the model to estimate the total NHS cost of patient management from the time a patient entered the dataset (i.e. from 1 May 2012 or the start time of their wound if it occurred later and the equivalent date in the matched control) up to the time their wound healed or the end of the study period, whichever came first. Differences between cases and controls were considered to be attributable to wound care and associated comorbidities.

The THIN database contained an estimated 135 000 patients with a wound that matched the study protocol's inclusion and exclusion criteria, drawn from a base population of 3·9 million active patients. The whole UK population was an estimated 63·7 million people in mid-2013, of which 49·7 million people were adults. Using these variables, the outputs of the modelling were extrapolated to the whole adult population in the UK, as previously described (1). Accordingly, the model estimated that there were 2·2 million patients with a wound who matched the study protocol's inclusion and exclusion criteria, equivalent to 4·5% of the adult population.

Sensitivity analyses

Deterministic sensitivity analyses were performed on all of the model's inputs to identify how the cost of wound management and associated comorbidities would change by varying different parameters in the model.

Two methods were used to adjust for the cost of managing patients' comorbidities:

1 The first involved generating an incremental cost among control patients between those who had no comorbidities and those who had one, two, three, four, five or more comorbidities. These incremental costs were then applied to both groups so that all the patients were modelled to have the maximum number of comorbidities. The resulting cost difference between the two groups was considered to be solely because of the wounds.

2 The second method involved the removal of a case–control match from the analysis if they did not have the same number of comorbidities. The resulting cost difference between the two groups was considered to be solely because of the wounds.

Results

Patients' characteristics

The mean age of the cases was 69·0 years, and 45% were male. Eighteen percent of the cases were smokers, 39% were non-smokers and 40% were ex-smokers, and these were not significantly different from the controls. Seventy-six percent of cases presented with a new wound in the study year (patients' records predated the onset of the study period, enabling both pre-existing and new wounds to be identified; a similar process allowed wound-healing to be characterised). There was no evidence that patients in the dataset had more than one wound. However, 72% of patients had a wound a mean 4·9 years prior to the one being evaluated in the study period. Table 1 summarises this data according to wound type.

Significantly more patients with a wound (94%) than control patients (77%) had at least one comorbidity in the year before the start of their wound ($P < 0{\cdot}001$). The comorbidities associated with patients with different wound types in terms of the percentage of patients with different comorbidities in the year before the start of their wound (and not necessarily the year before the start of the study period) is summarised in Table 2.

The percentage of patients in both groups with different numbers of comorbidities, stratified by age, is summarised in Table 3. This table shows that as many as 42% of controls ≤45 years of age (i.e. members of the general public) have two or more comorbidities, and 23% have three or more comorbidities.

Binary logistic regression was performed on patients' age, gender, smoking status and all comorbidities. Those variables that yielded a P value ≥0·05 were omitted from the analysis, resulting in the prior presence of cardiovascular disease, dermatological symptoms, gastrointestinal symptoms, neurological

Table 2 Percentage of patients with different comorbidities in the year before the onset of their wound, stratified by wound type

	Abscess (%)	Burn (%)	Diabetic foot ulcer (%)	Leg ulcer (arterial) (%)	Leg ulcer (mixed) (%)	Leg ulcer (unspecified) (%)	Leg ulcer (venous) (%)	Open wound (%)	Pressure ulcer (%)	Surgical wound (%)	Trauma (%)	Unspecified (%)
Cardiovascular	11	21	42	0	27	26	11	16	22	20	13	23
Dermatological	29	18	28	0	36	43	47	29	41	27	30	25
Endocrinological	18	15	58	50	18	11	6	16	32	16	7	15
Gastroenterological	21	26	22	0	27	13	14	17	38	25	8	19
Musculoskeletal	11	21	14	25	36	13	10	18	20	21	15	35
Neurological	0	13	24	25	9	8	5	9	26	5	13	13
Nutritional deficiency	7	10	29	0	55	22	8	24	51	20	7	20
Psychiatric	0	18	21	0	9	11	2	15	33	11	14	12
Respiratory	11	8	14	25	18	14	3	21	9	7	20	19

Table 3 Percentage of patients with different number of comorbidities during the year before the onset of their wound, stratified by age

	Percentage with ≥1 comorbidity (%)		Percentage with ≥2 comorbidities (%)		Percentage with ≥3 comorbidities (%)	
Age group (years)	Cases	Controls	Cases	Controls	Cases	Controls
<30	72	55	43	26	34	13
30–45	89	50	68	16	47	10
46–60	94	68	79	45	68	22
61–75	95	77	88	57	76	35
>75	98	89	91	74	82	54

symptoms, nutritional deficiency and respiratory disease being considered independent risk factors for developing different wound types:

- Cardiovascular disease, an independent risk factor for developing a pressure ulcer [odds ratio (OR) 3·40 (95% confidence interval (CI): 1·43; 8·10); $P = 0·006$] and a diabetic foot ulcer [OR 2·66 (95% CI: 1·21; 5·83); $P = 0·02$]
- Dermatological symptoms, an independent risk factor for developing a venous leg ulcer [OR 3·44 (95% CI: 2·34; 5·10); $P < 0·001$] and an open wound [OR 1·78 (95% CI: 1·18; 2·68); $P = 0·006$]
- Gastrointestinal symptoms, an independent risk factor for developing a pressure ulcer [OR 1·85 (95% CI: 1·10; 3·12); $P = 0·02$] and a surgical wound [OR 1·82 (95% CI: 1·24; 2·66); $P = 0·002$]
- Neurological symptoms, an independent risk factor for developing a pressure ulcer [OR 2·16 (95% CI: 1·29; 3·61); $P = 0·003$]
- Nutritional deficiency, an independent risk factor for developing a pressure ulcer [OR 4·52 (95% CI: 2·66; 7·71); $P < 0·001$] and an open wound [OR 1·64 (95% CI: 1·07; 2·49); $P = 0·022$]
- Respiratory disease, an independent risk factor for developing an open wound [OR 1·60 (95% CI: 1·05; 2·45); $P = 0·03$]

Clinical outcomes

Sixty-one percent of all wounds healed in the study year; 79% of acute wounds and 43% of chronic wounds healed. The healing rate of each wound type is shown in Table 1. Binary logistic regression suggests that nutritional deficiency [OR 0·53 (95% CI: 0.41; 0.70); $P < 0·001$] and diabetes [OR 0·65 (95% CI: 0.50; 0.85); $P < 0·001$] were independent risk factors for non-healing during the study period. In addition, 4% of patients with a wound and 1% of control patients died in the study year.

Health care resource use associated with patient management

Patients were predominantly managed in the community by GPs and nurses. Table 4 shows the annualised resources associated with each wound type and the associated comorbidities.

Assessment of peripheral perfusion is a recognised requirement for leg ulcer and diabetic foot management, yet only 16% of all cases with a leg or foot ulcer had a Doppler ankle brachial pressure index (ABPI) recorded in their records, of which 81% were treated with compression. Of the 84% that did not have their ABPI recorded, 46% were treated with compression (Table 5).

The total annual NHS cost of managing 2·2 million wounds and associated comorbidities was estimated to be £5·3 billion. This ranged from £982·9 million for surgical wounds to £46·5 million for arterial leg ulcers (Table 6).

It was estimated that 1·3 million wounds healed (61%) and 0·9 million remain unhealed (39%) during the study period. Moreover, resource use associated with managing the unhealed wounds was substantially greater than that of managing the healed wounds (Table 7). Consequently, the annual cost of managing wounds that healed was estimated to be £2·1 billion compared with £3·2 billion for the 39% of wounds that did not heal within the study year. Furthermore, the estimated cost of wound products associated with managing the 1·3 million wounds that healed was £190 million compared with

Table 4 Annual amount of National Health Service (NHS) resource use attributable to managing 2·2 million wounds and associated comorbidities, stratified by wound type

Wound type	Annual number of wounds	GP visits (million)	Practice nurse visits (million)	Community nurse visits (million)	Specialist nurse visits	Allied health care visits	Hospital outpatient visits	Hospital admissions and day cases	Diagnostic tests (million)	Non-wound-devices (million)	Wound care products (million)	Drug prescriptions (million)
Abscess	159 983	0·56	1·33	0·50	2221·99	15 405·10	256 665·47	117 765·56	1·53	10·38	14·47	4·24
Burn	86 658	0·13	0·46	0·09	0·00	2200·73	94 330·05	11 109·96	0·27	3·66	3·44	2·23
Diabetic foot ulcer	168 871	0·77	1·15	1·33	8887·97	145 248·09	482 618·84	33 329·87	4·92	69·82	34·06	12·78
Leg ulcer (arterial)	8888	0·02	0·20	0·17	0·00	2200·73	6581·16	6665·97	0·06	3·26	3·78	<0·01
Leg ulcer (mixed)	24 442	0·18	0·29	0·36	0·00	4401·45	21 937·22	17 775·93	1·23	0·92	14·58	2·50
Leg ulcer (unspecified)	419 956	1·92	4·78	1·99	17 775·93	37 412·39	669 085·22	124 431·53	8·48	26·84	78·30	20·95
Leg ulcer (venous)	277 749	0·91	4·64	2·10	4443·98	44 014·57	456 294·18	106 655·60	5·33	36·24	93·23	15·38
Open wound	239 975	0·76	1·44	0·81	4443·98	55 018·22	300 539·91	73 325·72	4·20	10·46	26·30	8·32
Pressure ulcer	153 317	0·70	0·37	1·60	6665·97	33 010·93	221 565·92	33 329·87	2·54	28·89	28·00	9·65
Surgical wound	253 307	0·73	1·84	0·82	2221·99	28 609·47	410 226·02	328 854·76	3·52	42·42	25·28	7·65
Trauma	157 761	0·41	0·67	0·23	0·00	33 010·93	144 785·66	62 215·77	1·04	11·87	7·68	3·65
Unspecified	271 083	0·60	1·39	0·85	0·00	59 419·67	383 901·36	53 327·80	3·10	27·97	25·85	9·93
Total	2 221 992	7·69	18·56	10·86	46 661·82	459 952·27	3 448 531.01	968 788·35	36·22	272·73	354·95	97·28

Table 5 Use of Doppler in patients with a lower leg ulcer to measure ankle brachial pressure index

Ulcer type	Percentage who had a Doppler (%)	Percentage who did not have a Doppler (%)	Percentage of these who received compression (%)	Clinician who performed the Doppler (%)				
				Practice nurse	Community nurse	GP	Outpatient nurse	Unknown
VLU	22		85	79	14	3	0	4
		78	59					
Unspecified leg ulcer	15		86	76	10	7	7	0
		85	38					
DFU	5		75	80	0	0	20	0
		95	18					

VLU, venous leg ulcer; DFU, diabetic foot ulcer

£560 million for the 0·9 million that did not heal (Table 7). The only clinical difference that could be detected between healed and unhealed wounds was that 28% of patients with a healed wound had nutritional deficiency before the onset of the wound compared with 42% of patients with an unhealed wound ($P < 0·04$).

Sixty-six percent of the total annual NHS cost was incurred in the community and the remainder in secondary care. However, the distribution of costs varied according to wound type, with 48% and 78% of the total annual NHS cost of managing acute and chronic wounds, respectively, being incurred in the community and the remainder in secondary care.

Sensitivity analyses

The estimated annual number of each wound type was individually reduced and increased by 25%. This had the effect of changing the total annual NHS cost of managing wounds and associated comorbidities by 5% or less. The estimated amounts of individual resource use were varied by +/− 25%. However, this only affected the total annual NHS cost of managing 2·2 million wounds and associated comorbidities by 6% or less.

When the NHS cost of managing patients was adjusted for their comorbidities (see description of methods 1 and 2 sections under Sensitivity Analyses in Methods), the total annual NHS cost of managing 2·2 million wounds was reduced from £5·3 billion to £5·1 billion when method 1 was used and to £4·5 billion when method 2 was used (Table 8). Hence, the total annual NHS cost of managing the comorbidities among 2·2 million patients with a wound was estimated to be between £250 and £788 million. After adjusting for comorbidities, the total annual NHS cost of managing healed wounds and unhealed wounds was estimated to be £1·9 billion and £2·9 billion, respectively.

In addition, within the study period, the cost per healed wound ranged from £698 to £3998 per patient and that of an unhealed wound ranged from £1719 to £5976 per patient. After adjusting for comorbidities, the per patient cost of healed wounds was reduced by a mean 12% compared with 8% for unhealed wounds (Table 9). In addition, the per patient cost of an unhealed wound was a mean 135% more than that of a healed wound.

Table 6 Annual cost (£ million) of National Health Service (NHS) resource use attributable to managing 2·2 million wounds and associated comorbidities, stratified by wound type

Wound type	GP visits	Practice nurse visits	Community nurse visits	Specialist nurse visits	Allied health care visits	Hospital outpatient visits	Hospital admissions and day cases	Diagnostic tests	Non-wound devices	Wound care products	Drug prescriptions	*Total
Abscess	£27·70	£17·30	£33·06	£0·14	£0·84	£31·23	£82·60	£8·77	£4·83	£42·18	£40·46	£289·51
Burn	£4·21	£6·01	£6·25	£0·00	£0·16	£11·96	£9·10	£1·60	£4·08	£9·63	£36·54	£89·56
Diabetic foot ulcer	£37·56	£14·93	£77·35	£0·76	£8·29	£62·98	£51·63	£20·97	£19·53	£60·72	£199·23	£554·14
Leg ulcer (arterial)	£0·81	£2·57	£10·84	£0·00	£0·13	£0·83	£21·11	£0·51	£0·32	£7·19	£2·40	£46·45
Leg ulcer (mixed)	£7·91	£3·81	£24·33	£0·00	£0·21	£0·00	£22·49	£7·58	£3·24	£25·63	£20·84	£113·69
Leg ulcer (unspecified)	£94·11	£62·16	£133·00	£1·34	£2·68	£80·10	£72·75	£39·35	£16·66	£144·60	£189·60	£836·62
Leg ulcer (venous)	£44·82	£60·31	£131·27	£0·27	£2·86	£56·92	£102·33	£28·90	£23·94	£168·08	£319·48	£941·13
Open wound	£33·72	£18·78	£49·61	£0·28	£2·74	£35·63	£64·57	£12·45	£1·36	£122·24	£68·05	£409·73
Pressure ulcer	£39·63	£4·85	£88·43	£0·41	£2·54	£28·03	£63·93	£10·73	£131·12	£52·45	£108·86	£531·14
Surgical wound	£32·19	£23·89	£52·37	£0·13	£1·33	£47·95	£623·48	£19·71	£50·87	£55·26	£75·45	£982·90
Trauma	£18·94	£8·67	£15·81	£0·00	£2·30	£16·16	£35·06	£1·10	£2·20	£10·02	£51·17	£159·25
Unspecified	£27·42	£18·08	£57·04	£0·00	£5·52	£45·74	£49·98	£17·75	£6·58	£44·71	£90·00	£363·62
TOTAL	£369·04	£241·36	£679·36	£3·33	£29·59	£415·05	£1199·02	£169·41	£264·74	£742·70	£1202·07	£5317·72

*The cost of (1) ambulance services and (2) accident and emergency attendances are not shown but included in the total.

Table 7 Annual amount and corresponding cost of National Health Service (NHS) resource use attributable to managing 2·2 million wounds and associated comorbidities, stratified by healing

	Annual number (thousand)			Annual cost (£ million)		
	Healed	Unhealed	Percentage difference in resource use (%)	Healed	Unhealed	Percentage difference in resource cost (%)
Number of wounds	1351	871				
GP visits	3620	4073	13	£171·94	£197·10	15
Practice nurse visits	8450	10 110	20	£109·91	£131·46	20
Community nurse visits	3571	7286	104	£228·97	£450·39	97
Specialist nurse visits	24	22	−9	£1·78	£1·54	−13
Allied health care visits	156	304	96	£11·31	£18·28	62
Hospital outpatient visits	1584	1864	18	£184·34	£230·71	25
Hospital admissions and day cases	549	420	−23	£643·52	£555·50	−14
Ambulance services	2	7	200	£0·51	£1·53	200
Diagnostic tests	16 625	19 591	18	£78·53	£90·88	16
Devices	98 503	174 230	77	£121·93	£142·81	17
Wound care products	104 545	250 396	140	£185·41	£557·11	200
Drug prescriptions	40 433	56 657	40	£375·45	£826·81	120
Total				£2113·20	£3204·52	52

Discussion

This article reports the health economic burden that different wound types imposed on the NHS in 2012/2013. After adjustment for comorbidities, the annual NHS cost of managing 2·2 million wounds was estimated to be £4·5–5·1 billion. Of these wounds, it was estimated that 1·3 million wounds healed (61%) and 0·9 million remained unhealed (39%). Moreover, resource use associated with managing the unhealed wounds was substantially greater than that of managing the healed wounds (20% more practice nurse visits, 104% more community nurse visits, 13% more GP visits, 18% more hospital outpatient visits, 40% more drug prescriptions). Consequently, the annual cost of managing wounds that healed was estimated to be £2·1 billion compared with £3·2 billion for the 39% of wounds that did not heal within the study year. This is consistent with other evidence that the total time to healing was an important factor in driving the cost in terms of dressing frequency, product costs and nursing time (7). In addition, the mean cost of an unhealed wound per patient was approximately 2·5 times more than that of a healed wound during the study period. The cost driver for wound care was found to be the probability of wounds not healing and that nutritional deficiency (OR 0·53; $P < 0.001$) and diabetes (OR 0·65; $P < 0.001$) were independent risk factors for non-healing. Moreover, the only clinical difference that was detected between healed and unhealed wounds was the percentage of patients with nutritional deficiency (28% versus 42% for patients with a healed and unhealed wound, respectively).

Table 8 Annual cost of National Health Service (NHS) resource use attributable to managing 2·2 million wounds after adjusting for comorbidities

Wound type	Total annual NHS cost (£ million) attributable to wound care	
	After adjustment for comorbidities using method 1	After adjustment for comorbidities using method 2
Abscess	£274·26	£290·50
Burn	£79·29	£77·88
Diabetic foot ulcer	£524·63	£727·98
Leg ulcer (arterial)	£46·69	£46·45
Leg ulcer (mixed)	£110·82	£346·38
Leg ulcer (unspecified)	£778·90	£539·48
Leg ulcer (venous)	£921·94	£596·55
Open wound	£387·23	£136·08
Pressure ulcer	£506·99	£530·68
Surgical wound	£957·41	£985·78
Trauma	£143·30	£76·79
Unspecified	£335·93	£174·99
Total	£5067·38	£4529·53

This and other studies (8–11) show that wound management is predominantly a nurse-led discipline. Despite this, there would appear to be minimal clinical involvement of tissue viability nurses and other specialist nurses (Table 4). In addition, dressing and bandage types were continually switched at successive wound dressing changes, indicating confusion and conflict within the treatment plan. Moreover, an estimated 30% of all wounds being managed within the NHS lacked a differential diagnosis. This may be indicative of the difficulties experienced by non-specialist health care professionals in the community with establishing a working diagnosis. Furthermore, only 16% of patients with a lower leg ulcer or diabetic foot ulceration underwent a vascular assessment with the Doppler ABPI, although national guidance requires arterial assessment by Doppler ultrasound measurement of the ABPI (12,13). It remains unclear why this essential investigation was not routinely performed. Low levels of Doppler assessment have been reported previously, and the lack of use of ABPI as a screening tool may contribute to the lower prevalence of arterial leg ulcers than would be expected from previously published data (14).

The wound patients had significantly more comorbidities than their matched controls. Only 6% of cases and 23% of controls had no comorbidities ($P < 0{\cdot}001$). However, it was surprising to find such a high level of illness among the controls. For example, 55%, 26% and 13% of controls <30 years of age had at least one or more, two or more or three or more comorbidities, respectively. The THIN dataset in this study covers the period 2012/2013 and comprises patients with a wide age range (19–98 years), so this level of illness may be a proxy for the health of the general population at that time. Furthermore, the presence of nutritional deficiency was an independent risk factor for wound non-healing. Hence, community prevention of patients developing nutritional deficiency should help improve healing rates following the onset of a wound. Moreover, if patients' wounds and their comorbidities were treated more holistically with appropriate involvement of allied health care professionals, rather than just focusing on the wounds, better health outcomes might be achieved at lower cost.

This study has demonstrated a lack of evidence-based wound care (lack of differential diagnosis), treatment at times deviated from approved guidelines (few Doppler tests being performed), lack of senior engagement in wound care delivery and lack of continuity and consistency of wound care and treatment planning. The NHS Five-Year Forward View (5YFV) (15) identified a national need for a different integrated model of health and social care, which is 'joined up' and which addresses the needs of patients with long-term illnesses. Clearly, wound care requires such a change in its service delivery model. This could be achieved by:

- Enhanced support for safe self-care (possibly by integration with local pharmacy support and supervision).
- Improved diagnostic support underpinned by increased training and education of non-specialist nurses in the fundamentals of wound management and faster adoption of advanced medical devices with proven clinical effectiveness.
- An integrated progressive care pathway with agreed defined trigger points for senior involvement and onward referral for investigation and differential diagnosis and a shared management plan to be implemented regardless of care setting.
- Consistent and integrated care with unified supporting documentation, including joined-up management by health and social care, wider commissioning and involvement of qualified tissue viability specialists and dedicated wound care clinics in the community.
- Holistic assessment of patients recognising that patients' comorbidities impact the probability of wound development and healing.

These measures should help overcome some of the problems encountered in clinical practice and achieve better outcomes in terms of (a) wound prevention, (b) accuracy of diagnosis and (c) wound-healing rates. In turn, these actions should lessen workload and associated health care resource use and lead to reductions in the cost of wound care.

Previous studies have estimated the cost of some wound types. One such study estimated the annual NHS cost of treating patients with venous ulceration to be £168–198 million and £300 million for diabetic foot ulcers (16). These costs are lower than our estimates and probably reflect that study's limitations of indirectly extrapolating costs from small sample sizes. In addition, the annual NHS cost of managing pressure ulcers was estimated to be £1·8–2·6 billion (16). This cost is substantially higher than our estimate of £531 million. The difference may be because of people residing in nursing homes not having been included in our study. It may also be because of under-recording of pressure ulcers in patients' records and/or an over-estimation in the previous studies and/or a lower prevalence in 2012/2013 than in 2005/2006. Nevertheless, there has been much discussion in the literature about the cost to heal pressure ulcers. Bennett *et al.* estimated that the mean cost of healing a pressure ulcer ranged from £1064 per patient for an uncomplicated category I ulcer to £10 551 per patient for a category IV ulcer (17).

Table 9 Total annual National Health Service (NHS) cost of wound care attributable to managing 2·2 million wounds and associated comorbidities and cost per patient, stratified by healing

	Total annual NHS cost (£ million)				Mean annual NHS cost per patient			
	Attributable to wound care and associated comorbidities		Attributable to wound care after adjustment for comorbidities		Attributable to wound care and associated comorbidities		Attributable to wound care after adjustment for comorbidities	
Wound type	Healed	Unhealed	Healed	Unhealed	Healed	Unhealed	Healed	Unhealed
Abscess	£191·34	£98·17	£187·71	£94·67	£1625	£2325	£1594	£2242
Burn	£70·46	£19·09	£42·91	£35·68	£933	£1719	£568	£3211
Diabetic foot ulcer	£128·41	£425·73	£181·70	£444·61	£1864	£4258	£2638	£4447
Leg ulcer (arterial)	£0·00	£46·45	£0·00	£46·57	£0	£5226	£0	£5239
Leg ulcer (mixed)	£35·53	£78·16	£41·48	£187·12	£3998	£5025	£4667	£12 031
Leg ulcer (unspecified)	£324·03	£512·59	£250·94	£408·25	£1657	£2284	£1283	£1819
Leg ulcer (venous)	£136·25	£804·88	£103·35	£655·89	£1039	£5488	£788	£4472
Open wound	£182·22	£227·51	£126·38	£135·27	£1065	£3303	£739	£1964
Pressure ulcer	£176·25	£354·88	£156·17	£362·67	£2644	£4095	£2343	£4185
Surgical wound	£584·57	£398·33	£582·74	£388·85	£3132	£5976	£3122	£5833
Trauma	£96·20	£63·05	£60·04	£50·00	£698	£3153	£436	£2500
Unspecified	£187·94	£175·68	£124·25	£131·21	£984	£2196	£650	£1640
Total/mean*	£2113·20	£3204·52	£1857·68	£2940·78	£1564*	£3679*	£1375*	£3376*

According to our study, the mean cost of managing a healed and unhealed pressure ulcer, after adjusting for comorbidities, was £2343 and £4185, respectively. In 2009/2010, the Northern Burn Care Network estimated the cost of UK burn care provision to be £140 million (18). This cost is substantially higher than our estimate of £89·6 million and may reflect that patients <18 years of age were excluded from our analysis. It may also reflect different costing methodologies and any differences in the annual prevalence of burns.

The advantages and disadvantages of using the THIN database for this study have been previously discussed (1). In summary, the advantage of using the THIN database is that the patient pathways and associated resource use are based on real-world evidence derived from clinical practice. The cost of managing the comorbidities was estimated to be between £250 and £788 million. Nevertheless, the possibility of resource use associated with managing a comorbidity being conflated with that of wound management cannot be excluded. While the study results are compelling, the analyses were based on clinicians' entries into their patients' records and inevitably subject to a certain amount of imprecision and lack of detail. Moreover, the computerised information in the THIN database is collected by GPs for clinical care purposes and not for research. Prescriptions issued by GPs and practice nurses are recorded in the database, but it does not specify whether the prescriptions were dispensed or detail patient compliance with the product. Despite these limitations, it is the authors' opinion that the THIN database affords one of the best sources of real-world evidence for clinical practice in the UK.

The analysis does not consider the potential impact of those wounds that remained unhealed beyond the study period. No assumptions were made regarding missing data, and there were no interpolations. The THIN database may have under-recorded use of some health care resources outside the GP's surgery if not documented in the GP records, and the impact of this was addressed in sensitivity analyses. The analysis excludes hospital-based prescribing, but this should have minimal impact on the results as most prescribing is undertaken by GPs and nurses in the community. Also excluded is the potential impact of managing patients with wounds being cared for in nursing/residential homes.

The analysis only considered the annual cost of NHS resource use for the 'average adult patient', and no attempt was made to stratify resource use and costs according to gender, comorbidities, wound size, wound severity and other disease-related factors. Also excluded were the costs incurred by patients and indirect costs incurred by society as a result of patients taking time off work.

Notwithstanding the study's limitations, the real-world evidence highlights the substantial burden that wounds impose on the NHS in an average year. Clinical and economic benefits to both patients and the NHS could accrue from strategies that focus on (a) wound prevention, (b) accurate diagnosis and (c) improving wound-healing rates.

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Disclaimer

The study's sponsors had no involvement in the study design, the collection, analysis and interpretation of the data, the writing of this manuscript and the decision to submit this article for publication. The views expressed in this article are those of the authors and not necessarily those of the NHS, the NIHR, the Department of Health or any of the other sponsors.

Author Contribution

JFG designed the study, managed the analyses, performed some analyses, checked all the other analyses, and wrote the manuscript. NA and TM conducted much of the analyses. IU and AG conducted some of the analyses. DW scrutinised the analyses and edited the manuscript. KV and PV scrutinised the analyses, suggested further analyses, helped interpret some of the findings and edited the manuscript. JFG is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

The analyses have also been reviewed by the following strategic partners of the NIHR Wound Prevention and Treatment Healthcare Technology Co-operative (NIHR WoundTec HTC) (http://www.woundtec.htc.nihr.ac.uk): Professor Andrea Nelson, Head of School of Healthcare, University of Leeds, Leeds; Professor Jane Nixon, Deputy Director, Leeds Institute of Clinical Trials Research, Leeds; Professor Dan L Bader, Faculty of Health Sciences, University of Southampton, Southampton; Dr Patricia Grocott, Reader in Palliative Wound Care Technology Transfer, King's College, London; Hussein Dharma, Project Manager, NIHR WoundTec Healthcare Technology Co-operative, Bradford Institute for Health Research, Bradford.

Ethics approval

Ethics approval was obtained from Cegedim's Research Ethics Committee that appraises studies using the THIN database (reference number 13-061).

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