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ORIGINAL ARTICLE

Evaluating the cost of managing patients with cellulitis in Wales, UK: A 20-year population-scale study

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Abstract

This study aimed to estimate costs associated with managing patients with cellulitis from the UK National Health Service (NHS) perspective. The analysis was undertaken through the Secure Anonymised Information Linkage Databank, which brings together population-scale, individual-level anonymised linked data from a wide range of sources, including 80% of primary care general practices within Wales (population coverage ~3.2 million). The data covered a 20-year period from 1999 to 2019. All patients linked to the relevant codes were tracked through primary care settings, recording the number of general practice visits (number of days with an event recorded) and number of in-patient stays. Resources were valued in monetary terms (£ sterling), with costs determined from national published sources of unit costs. These resources were then extrapolated out to reflect UK NHS costs. This is the first attempt to estimate the financial burden of cellulitis using routine data sources on a national scale. The estimated direct annual costs to the Welsh NHS (£28 554 338) are considerable. In-Patient events and length of stay costs are the main cost drivers, with annual Welsh NHS estimates of £19 664 126 with primary care events costing £8 890 212. Initiatives to support patients and healthcare professionals in identifying early signs/risks of cellulitis, improve the accuracy of initial diagnosis, prevent cellulitis recurrence, and improve evidence-based treatment pathways would result in major financial savings, to both the Welsh and UK NHS. In light of these findings, Wales has developed the innovative National Lymphoedema cellulitis Improvement Programme to address these burdens; providing a proactive model of cellulitis care.

KEYWORDS
cellulitis, economic burden, longitudinal data, lymphoedema, SAIL databank

Key Messages

- the estimated costs associated with managing patients with cellulitis across two decades was examined at a national level.
- the estimated direct annual costs to the Welsh NHS are £28,554,338.
- in-Patient events and length of stay costs are the main cost drivers, with annual Welsh NHS estimates of £19,664,126.
- initiatives to support patients and healthcare professionals in identifying early signs/risks of cellulitis, improve the accuracy of initial diagnosis, prevent cellulitis recurrence, and improve evidence-based treatment pathways would result in major financial savings.
- wales has developed the innovative National Lymphoedema cellulitis Improvement Programme to address these burdens, providing a proactive model of cellulitis care.

1 | INTRODUCTION AND BACKGROUND

Cellulitis is a skin infection involving the dermis and sub cutaneous tissue and is usually caused by a break or wound in the skin, commonly allowing either staphylococcus or streptococcus bacteria to enter. Cellulitis is commonly interchanged with the term erysipelas and can affect any part of the body, however, 70%–80% are encountered in the lower limbs.[1-3] All age groups can be affected by cellulitis but it is more common in those over 60 years of age.[4] The signs and symptoms of a cellulitis include redness, erythema, pain, oedema, bullae, blisters, bruising, petechiae as well as nausea, vomiting, lethargy and rigours. Not all signs and symptoms may be present and mild cases that are detected promptly can be effectively managed in primary care with oral antibiotics. However, more severe cases with systemic toxicity, uncontrolled morbidities or tissue necrosis may require intravenous antibiotics and admittance to hospital. Antibiotics are administered to prevent the infection from spreading and reduce the risk of sepsis, which is potentially fatal. The link between cellulitis occurrence and lymphoedema is well documented with nearly 50% of people with lower limb lymphoedema reporting an episode of cellulitis and half of those experiencing another cellulitis within a year. Recurrent cellulitis is associated with reduced patient quality of life as it caused physical, psychological, and functional impacts. Other risk factors evidenced include wounds, obesity, fungal infections, and venous insufficiency.[5-9]

Antimicrobial resistance is a challenge globally; thus people with cellulitis should be accurately diagnosed and treated promptly and the risk factors adequately supported. Further, if these risk factors were reduced and the incidence of cellulitis was less then this would lead to reduced admissions, antibiotic costs, and financial savings.

There remains a dearth of knowledge concerning the economic costs associated with cellulitis from a whole National Health Service (NHS) system. In 2019–2020 over 37 000 Wales hospital bed days were recorded for cases of cellulitis admissions, but there is little understanding of the burden of cellulitis within primary care services.[4] This is surprising, given that proactive models of care support prompt and appropriate care, with the potential to mitigate the 1.4% of emergency admissions owing to cellulitis in the United Kingdom (UK) in 2018–2019.[10] Understanding the underlying contributory factors and comorbidities that increase the risk of cellulitis, including sex, age or social deprivation is also limited from a national perspective. By gaining a better understanding of these factors including the economic angle, it may be possible to prioritise care and reduce financial encumbrance on the NHS as a whole.

2 | AIMS AND OBJECTIVES

This study aimed to estimate the costs associated with managing patients with cellulitis from the perspective of the Welsh/UK NHS using routine electronic health record data sources available within the Secure Anonymised Information Linkage (SAIL) Databank.

Specific objectives of the study were as follows:

- To understand the financial burden of cellulitis on the Welsh/UK NHS.
- To establish the numbers of cases attending primary care.
- To better understand the incidence of cellulitis in Wales and the implicated costs for UK NHS.

3 | METHODS

The analysis was undertaken through the SAIL Databank,[11-13] sources within a privacy-protecting

Trusted Research Environment. These data include primary care events from 80% of general practices around Wales (population coverage ~3.2 million people), General Practitioner (GP) records and secondary care inpatient hospital episodes. All data are anonymised within SAIL, but the individual-level linkage is possible through an encrypted anonymised linking field which allows associations between data sources and longitudinal patient pathway analyses. The patient cohort was identified through relevant clinical codes and the resource implications of their management were collected and estimated using published sources.[14-18]

This approach provided an in-depth inventory of the contacts, consultations, and resources utilised in the current management of patients with cellulitis in NHS Wales.

3.1 | Inclusion/exclusion criteria

Patients with a cellulitis diagnosis in their Welsh Longitudinal General Practice (WLGP) records from 1999 to 2019 were included in the primary care cohort. Patients admitted and coded with cellulitis during their In-Patient stay were included in the secondary care cohort.

3.2 | Data analysis

The SAIL Databank was interrogated to catalogue health service resource utilisation by this cohort of patients. The WLGP data was used to identify and quantify all events in order to measure service usage. The Welsh Demographic Service Dataset (WDSD)[19] was utilised to gather basic demographics, information on follow-up time (residency in Wales and GP registrations), and the Welsh Index of Multiple Deprivation (WIMD)[20] version 2014 quintile to measure deprivation.

3.3 | Resource use

All patients linked to the relevant cellulitis codes (Table A1) were tracked through primary care settings, recording their level of general practice visits (number of days with an event recorded), and separately In-Patient admissions were captured including length of stays.

3.4 | Cost data

As highlighted in Table 1, resources were valued in monetary terms (£ sterling), and the costs were determined from nationally published sources of unit costs, including the Personal and Social Services Research Unit (PSSRU) unit costs[16] and costings derived from the NHS Wales Financial Delivery Unit.[17] Where costs were unavailable, local costs were utilised (eg, from local financial records or NHS Wales formulary). The currency year was 2020 and an inflation calculator (Bank of England-BOE) was used to convert previous years' costs to current prices.

TABLE 1 Age distribution of cellulitis in a primary care cohort Wales 1999–2019 and population distribution by the Welsh Index of Multiple Deprivation (WIMD)

Age group	N
0–10	28 712
11–20	21 284
21–30	21 628
31–45	46 420
46–60	58 083
61–75	60 983
76–90	34 586
91+	2999
N/A + Missing data	<800
WIMD Quintile 2014	**N**
1 Most deprived	60 690
2	56 535
3	56 801
4	48 190
5 Least deprived	52 487
Total	274 703

3.5 | Perspective

The perspective taken was from NHS Wales and extrapolated to the UK NHS.

3.6 | Statistical analysis

Statistical analysis was undertaken in SPSS Version 25 for Windows. Further, basic descriptive demographic statistics were also collected alongside the resource use and cost data. Survival analysis of treatment duration was conducted using R 3·5.

3.7 | Ethics approval and consent to participate

Approval for the use of anonymised data in this study, provisioned within SAIL Databank was granted by an

TABLE 2 Estimated cost of WLGP events over 20-years

		GP EVENTS	General Practitioner	NURSE
SURGERY VISIT	UNIT COST	-	£39	£42
	%	82%	62%	38%
	NO.	2 858 607	1 772 336	1 086 271
	COST	-	£69 121 115	£45 623 366
		GP EVENTS	**General Practitioner**	**NURSE**
TELEPHONE	UNIT COST	-	£16	£7.80
	%	15%	62%	38%
	NO.	522 916	324 208	198 708
	COST	-	£5 031 706	£1 549 923
		GP EVENTS	**General Practitioner**	**NURSE**
HOME VISIT	UNIT COST	-	£134	£84
	%	3%	62%	38%
	NO.	104 583	64 842	39 742
	COST	-	£8 688 771	£3 338 295
	TOTAL NO.	3 486 106	2 161 386	1 324 720
	TOTAL COST	-	£82 841 592	£50 511 584

independent Information Governance Review Panel (IGRP) under project 1061. The IGRP has a membership comprised of senior representatives from the British Medical Association (BMA), the National Research Ethics Service (NRES), Public Health Wales, and NHS Wales Informatics Service (NWIS).[18] Usage of additional data was granted by data owner. The SAIL Databank is General Data Protection Regulations and the UK Data Protection Act compliant.

The report utilised primary care data between January 1st 1999 and December 31st 2019 from the SAIL Databank, WLGP[19] records, in-patient hospital admissions from the PEDW[14] data, week of birth and sex were obtained from the WDSD[20] and deaths from the Annual District Death Extract (ADDE) based on the Official for National Statistics (ONS) deaths dataset (ADDE). Around 6% of the data, (approximately 18 400 records) were lost to quality assurance and missing Lower Layer Super Output Area code (LSOA) and hence deprivation quintiles. A small number were also lost due to the quality assurance for missing data carried out on the in-patient hospital admission data. In addition, patient cases that had several duplicate in-patient hospital admissions on the same day were removed, only keeping the one admission with the longest duration. Some cases may still have two admissions for the same date but have different ICD-10 cellulitis codes. These records have been kept but are only counted as one admission.

The index date is the first date found in either the WLGP records or the hospital records using PEDW for a diagnosis of cellulitis. Most of the index dates are found in the WLGP records but a small number (just under 4500) have a hospital admission for cellulitis before they are seen by a GP, so for those cases, the first hospital admission date is used.

4 | RESULTS

4.1 | Cohort demographics

Of the cohort of 274 703, 47% (n = 128 464) were male and 53% female (n = 146 238). The overall mean age of the cohort was 63.9 (Median 68 years). By sex, the mean age of females was 66.9 and 60.6 years for males. Table 1 shows the spread of the cohort across the 8 age groups assigned. The biggest share of the cohort was 61–75 (n = 60 983), 46–60 (n = 58 083), and 31–45 (n = 46 420).

Of the cohort of 274 703, 22% (n = 60 690) were in the WIMD Quintile 1 (Most Deprived); 21% (n = 56 535) were in the WIMD Quintile 2; 21% (n = 56 801) were in the WIMD Quintile 3; 17% (n = 49 190) were in the WIMD Quintile 4 and 19% were in the Quintile 5 (Least Deprived) (n = 52 487) as shown in Table 1.

4.2 | Cost of general practice event days

Not all days with an event represent consultations with a GP. Some are prescription renewals, receipt of letters from

TABLE 3 Incidence of cellulitis in GP Events and hospital admissions

Year	GP Patient events	Incidence per 1000	Hospital events	Incidence per 1000
2010	96 449	39	3116	1.3
2011	97 075	39	3245	1.3
2012	100 496	41	3159	1.3
2013	96 610	39	3198	1.3
2014	93 958	38	3507	1.4
2015	90 382	36	3601	1.5
2016	88 129	36	3819	1.5
2017	83 167	34	3704	1.5
2018	80 226	32	3906	1.6
2019	75 493	30	3902	1.6

hospital and other activities. There is no reliable way from the data held in SAIL to identify the number of patient consultations with a GP. Therefore, a pragmatic approach to defining and costing a primary care contact was taken. With a breakdown of GP and nurse-led contacts, based on previous research[21] it was assumed that 82% of consultations were conducted at the surgery, 12% of consultations were over the telephone and 3% were either home visits or conducted at other locations.[21] For ease of analysis and to combat the unknown quantity of 'other locations', the 3% conducted at other locations were added to the telephone consultations to make them 15% of all contacts.

Additionally, the cited study[21] disaggregated the numbers further, by assuming that 62% of the above-mentioned consultations were undertaken by GPs, 34% were undertaken by Practice Nurses and 4% by other clinicians. Again, for ease of analysis and the unknown quantity of 'other clinicians', the 4% of other clinicians were classed as being undertaken by practice nurses (Table 2).

Table 3 shows the incidence of cellulitis during the last 10 years in primary and secondary care in NHS Wales as reported by WLGP records using the population of Wales as 2.48 million as only 80% of GP data are captured.

The unit costs for health care utilisation were obtained from several PSSRU sources[16] and are shown in Table A2.

The number of GP events was observed from the SAIL Databank were 3 486 106 (£133 353 176) over the 20-year period. Using the assumption as laid out above, a breakdown of those events is shown in Table 4. Of the 3 486 106 GP events identified over the 20-years, 2 858 607 were deemed a surgery visit, with 1 772 336 (£69 121 115) deemed a GP visit and 1 086 271 (£45 623 366) deemed a Practice Nurse visit.

Additionally, 522 916 were deemed a Telephone call, with 324 208 (£5 031 706) estimated as GP Telephone call and 198 708 (£1 549 923) considered a Telephone call with the Practice Nurse.

Finally, 104 583 were deemed a Home Visit, with 64 842 (£8 688 771) supposed a GP Home Visit and 39 742 (£3 338 295) considered a Practice Nurse Home Visit.

The total resource use over the 20 years demonstrates that female patients accounted for £240 936 917 compared to £170 887 185 for male patients (Table 4).

When the resource use is reviewed alongside the age group, the biggest share of the expenditure was for the 76–90 age group with £132 217 754 followed closely by the age group 91+ with £124 928 422 across the 20-years (Table 4).

Overall cellulitis expenditure by WIMD quintiles in Table 5 showed that total resource usage expenditure was highest in WIMD Quintile area 1 (Most Deprived) with £97 939 134 (or a mean per-person cost of £1614). For the cost of WLGP Events/Contacts the total resource usage was £32 075 934 (or a mean per-person cost of £529) and for the cost of PEDW Admissions, the total resource usage was £65 863 200 (or a mean per-person cost of £6728).

This is in comparison to the overall cellulitis expenditure WIMD Quintile area 5 (Least Deprived) with £66 056 449 (or a mean per-person cost of £1259). For the cost of WLGP Events/Contacts the total resource usage was £22 482 945 (or a mean per-person cost of £428) and for the cost of PEDW Admissions, the total resource usage was £43 573 504 (or a mean per-person cost of £6632).

Table 6 shows an overall summary of resource usage costs as observed in the SAIL Databank over the 20-year period. With the observed number of patients of 274 703,

TABLE 4 Estimated overall resource use costs by sex and age-group over 20-years

Sex		Total cost	Cost admissions (PEDW)	Cost of GP events (WLGP)
Male	Mean	£1330	£5838	£416
	N	128 464	20 116	128 464
	Sum	£170 887 185	£117 440 544	£53 446 641
	Std. deviation	£5429.36	£12 346.50	£555.92
Female	Mean	£1648	£8203	£546
	N	146 238	19 631	146 238
	Sum	£240 936 917	£161 030 688	£79 906 229
	Std. deviation	£6753.47	£16 501.09	£695.46
Age group		**Total cost**	**Cost PEDW admissions**	**Cost of WLGP events**
0–10	Mean	£214	£779	£145
	N	4667	411	4667
	Sum	£999 077	£320 320	£678 757
	Std. deviation	£356.05	£789.68	£143.37
Nov-20	Mean	£311	£878	£253
	N	12 883	855	12 883
	Sum	£4 006 960	£750 464	£3 256 496
	Std. deviation	£391.19	£922.51	£217.81
21–30	Mean	£385	£1093	£319
	N	18 428	1105	18 428
	Sum	£7 088 508	£1 208 064	£5 880 444
	Std. deviation	£532.99	£1361.42	£300.78
31–45	Mean	£557	£1941	£381
	N	31 636	2873	31 636
	Sum	£17 635 658	£5 576 896	£12 058 762
	Std. deviation	£1494.20	£4145.18	£428.61
46–60	Mean	£955	£3743	£456
	N	45 802	6097	45 802
	Sum	£43 726 339	£22 820 096	£20 906 243
	Std. deviation	£4231.25	£10 717.80	£598.12
61–75	Mean	£1442	£5700	£571
	N	56 304	8605	56 304
	Sum	£81 216 952	£49 044 736	£32 172 216
	Std. deviation	£5900.48	£13 756.85	£757.39
76–90	Mean	£2172	£8733	£629
	N	60 882	10 756	60 882
	Sum	£132 217 754	£93 927 392	£38 290 362
	Std. deviation	£7370.88	£15 343.31	£783.97
91+	Mean	£2833	£11 590	£456
	N	44 093	9044	44 093
	Sum	£124 928 422	£104 819 520	£20 108 902
	Std. deviation	£9643.64	£18 490.59	£552.72

TABLE 4 (Continued)

Age group		Total cost	Cost PEDW admissions	Cost of WLGP events
Total	Mean	£1499	£7006	£485
	N	274 703	39 747	274 703
	Sum	£411 824 408	£278 471 232	£133 353 176
	Std. Deviation	£6171.70	£14 595.27	£637.40

TABLE 5 Estimated overall cost by WIMD Quintile 2014 over 20-years

WIMD Quintile 2014		Total cost	Cost PEDW admissions	Cost of WLGP events
1 Most deprived	Mean	£1614	£6728	£529
	N	60 690	9789	60 690
	Sum	£97 939 134	£65 863 200	£32 075 934
	Std. deviation	£6670.77	£15 172.03	£681.07
2	Mean	£1629	£7126	£508
	N	56 535	8896	56 535
	Sum	£92 098 102	£63 388 832	£28 709 270
	Std. deviation	£6636.23	£15 093.59	£670.38
3	Mean	£1489	£7135	£489
	N	56 801	7957	56 801
	Sum	£84 565 043	£56 772 768	£27 792 275
	Std. deviation	£5996.46	£14 314.02	£635.59
4	Mean	£1477	£7479	£463
	N	48 190	6535	48 190
	Sum	£71 165 680	£48 872 928	£22 292 752
	Std. deviation	£6029.26	£14 552.05	£608.40
5	Mean	£1259	£6632	£428
	N	52 487	6570	52 487
	Sum	£66 056 449	£43 573 504	£22 482 945
	Std. deviation	£5299.72	£13 346.23	£567.69
Total	Mean	£1499	£7006	£485
	N	274 703	39 747	274 703
	Sum	£411 824 408	£278 471 232	£133 353 176
	Std. Deviation	£6171.70	£14 595.27	£637.40

WLGP Events/Contacts were estimated at £133 353 176; PEDW Events were estimated at £294 961 888 and the total cost over the 20 years was estimated to be £428 315 064. Using the observed number of patients, the estimated annual cost of treatment was £21 415 753 per annum.

When extrapolated from the observed SAIL Databank to an all-Wales cohort of 3.2 million, the extrapolated cohort is estimated at 366271 patients. WLGP Events/Contacts were estimated at £177 804 235; PEDW Events were estimated at £393 282 517 and the total cost over the 20 years was estimated to be £571 086 752. Using the observed number of patients, the estimated annual cost of treatment was £28 554 338.

Finally, when extrapolated from the observed SAIL Databank to an estimated all UK cohort of 7 325 413 patients.

WLGP Events/Contacts were estimated at £3 556 084 697; PEDW Events were estimated at £7 865 650 347 and the total cost over 20 years was estimated to be £11 421 735 044. Using the observed number of patients, the estimated annual cost of treatment was £571 086 752 for the UK.

TABLE 6 Estimated overall summary of all costs as observed from the SAIL Databank, all Wales and UK perspective over 20-years

SAIL observed data	
No. of patients	**274 703**
WLGP events/contacts	£133 353 176
PEDW events	£294 961 888
Total over 20 years	£428 315 064
Estimated annual cost of treatment (n = 274 703)	£21 415 753
Wales	
No. of patients	366 271
WLGP events/contacts	£177 804 235
PEDW events	£393 282 517
Total over 20 years	£571 086 752
Estimated annual cost of treatment (n = 366 271)	£28 554 338
UK	
No. of patients	7 325 413
WLGP events/contacts	£3 556 084 697
PEDW events	£7 865 650 347
Total over 20 years	£11 421 735 044
Estimated annual cost of treatment (n = 7 325 413)	£571 086 752

5 | DISCUSSION

Economic perspectives on clinical conditions can be important at local, national and global levels. This is the first attempt to estimate the economic burden of cellulitis using the SAIL Databank for both primary and secondary care costs in the Welsh NHS. The direct costs are considerable (£28 554 338) and would represent 0.35% of the annual budget in Wales. In-Patient events and length of stay costs are the main cost drivers with annual estimates of £19 664 126. This is followed by primary care costs of £8 890 212. At a UK level, the cellulitis burden would amount to around £571 086 752 per annum with an average of £1499 per patient. One American paper[22] estimated cellulitis discharges in 2013 cost $3.74 billion (95% CI, $3.65 billion–$3.83 billion) with a median cost per visit of $5159. These costs are not directly comparable since only hospital data were used. Hospital admissions costs for Wales would be £7006 per patient (plus inflation).

Our study also reviewed the overall cellulitis expenditure by WIMD quintiles which demonstrated that resource usage expenditure was highest in WIMD Quintile area 1 (Most Deprived) with £97 939 134 (or a mean per-person cost of £1614), compared to £66 056 449 (or a mean per-person cost of £1259) for WIMD Quintile area 5 (Least Deprived). WIMD measures relative deprivation by geographical areas and takes into account factors such as income, employment, education, housing, and crime. More understanding is needed, but as cellulitis is associated with deprivation due to poor diet and nutrition, challenges with personal skin care, oedema management,[23-26] clothing, and environment, along with recreational substance misuse, the data presented here provides the impetus for risk reduction strategies.

One American study[27] reviewed cellulitis incidence using regional data from health insurance claims and found the rate to be 24.6 per 1000 people. They suggested that of male sex and increasing age were potential risk factors. We did not stratify the data per year to age and sex, but over the 20 years, we found that older age was a factor incurring most cellulitis costs in the 76–90 age group, with £132 217 754 followed closely by the age group 91+ with £124 928 422. In contrast, we did not establish that male sex was a risk factor with cellulitis incidence as our data suggested female sex was more dominant with 146 238 cases compared to males with 128 464 episodes. This is also contrary to a longitudinal Australian cohort study that also found male sex to be a risk factor for cellulitis.[27] However, our study was over 20-years, whereas others were over 10 and 3 years. Capturing incidence data via databanks uses codes rather than case reviews, so there is a possibility of data or coding errors. In this initial trial through the data, we did not distinguish between where on the body the cellulitis was located. Further data analysis may support or refute previous studies reporting a higher prevalence of lower limb cellulitis, but this could be a further paper.

Ellis Simonsen et al[28] also suggested that 78% of care for cellulitis was provided in an outpatient setting, whereas our data suggested that over the two decades, primary care provided 95% of the treatments. This is important and demonstrates that only those requiring emergency treatment were seen through acute hospital settings reducing the pressures on unscheduled care. However, with increasing pressures on general practice, this trend may alter as the incidence of hospital admissions has risen from 3116 to 3902 over the last 10-years.

Concern over antimicrobial resistance is important. Reducing inappropriate antibiotic use while expanding essential access is a difficult challenge at the international level and especially for low and middle-income countries. For UK-based health care, it remains a concern in secondary and primary care, therefore approaches that reduce the need for antibiotics are important. For example, the increasing evidence base that compression rather than prophylactic antibiotics is most useful in preventing recurrence of cellulitis, especially in the previously

difficult to treat/higher-risk patients is relevant. Cellulitis is integrally linked to lymphoedema/chronic oedema, not only as a precursor but one can significantly exacerbate the other in a vicious circle.[8] In a recent international study[1] involving 40 sites and 9 countries of 7477 chronic oedema patients, 16% had encountered cellulitis in the last 12 months with a prevalence of 37%. Other risk factors in Burian et al's study[1] included wounds, morbid obesity, obesity, midline oedema, male sex, and diabetes. Given the demonstrated financial encumbrance of cellulitis, a proactive model of cellulitis care, which includes lymphoedema/chronic oedema management to reduce the risk of cellulitis recurrence would seem logical.

Indeed, if prevention of cellulitis schemes could decrease the incidence by a modest 5%, the savings could be nearly 1.5 million per annum for the Welsh NHS alone (5% of £571 086 752, when extrapolated to the UK population = £28 554 337.6 for the UK). This information may nudge a change of practice, providing significant financial impact for health care providers and improved care for the patients at the fore. Possibly the best way of attacking these challenges is ensuring that there are local, regional, national, and international guidelines, protocols, algorithms and cellulitis care pathways with implementation monitoring.

Two decades ago Byford et al[29] criticised cost-of-illness (COI) studies for over-simplification, overestimation of savings and a lack of consideration of outcomes achieved. In this study, the assumptions have been made clear and acknowledging that not all costs can be saved, and that we propose a modest 5% saving. Methods of estimating the burden of costs of specific episodes of illness or particular conditions have expanded since then as access to larger data banks and more sophisticated software have developed. It is therefore important to acknowledge the strengths and limitations of the data used. SAIL data was previously used by members of the research team in 2016[29] and 2020.[30] Lessons learned in those previous studies (including issues with the use of READ codes, diagnosis, GP event definition, etc.) allowed for greater awareness of limitations in this study.

The purpose of this study was not to divert funding from one condition to another as Byford et al feared but to focus on one particular aspect which was considered 'changeable' by clinicians as a first step in understanding where efficiencies and improved patient experience could occur within a national service.

5.1 | Strengths and limitations

This study used data available within the SAIL Databank, covering nearly 80% of primary care data of the Welsh population, and 100% of secondary care data. Extrapolations made from this are likely to represent a realistic estimate of the problem. Although clinical coding may be an issue, we have tried to improve data quality using all cellulitis codes and are possibly more robust than voluntary reports of infections.

The study results provide an important reference point for policymakers in concerting resources and strategies in tackling the main cost drivers for this condition. While it is the ideal scenario in aiming for complete identification and treatment of cellulitis, this is not always possible, but it may be appropriate to target those with repeated recurrence and ensure cellulitis education is readily available for primary care, especially as they see the majority of the cohort.

The coding issues relating to GP events/contacts are limitation, which was addressed in the assumptions made. However, by using the existing evidence,[21] a reasonable assumption was made of the types of contact that patients would have with either the GP or the Practice Nurse. It must be noted that this was before the COVID-19 pandemic, where virtual consultations have taken precedence. Another limitation is using a database to portray incidence. The incidence rates are not verified by case reviews and there could be a miscoding element.

Whilst the population of Wales and the respective Welsh NHS is smaller in comparison to England in the UK, with health being a devolved matter, we believe there is strength in the joined up of nature of services and data availability in Wales, which enables translatable findings which are reflective of the UK NHS as a whole since practice in relation to cellulitis and overall demographics are similar. Importantly, we did not cost other health-related costs, such as the antibiotics or analgesia or the potential impact on the patient, such as loss of employment or quality of life.

The perspective of the Welsh NHS costs shows just one picture of the economic burden cellulitis has on the UK healthcare system. A wider, more societal perspective would shed light on further substantial costs relating to caregivers, loss of productivity, and health-related quality of life.

6 | CONCLUSION

Cellulitis is a common and expensive problem for the NHS. This large data analysis showed that estimated annual direct costs for NHS Wales are substantial (over £28 million). Extrapolated for the UK, this amounts to over £571 million. In-Patient events and length of stay costs are the main cost drivers, with annual Welsh NHS estimates of £19 664 126 with primary care events costing

£8 890 212. Initiatives to identify early signs/risks of cellulitis, improving the accuracy of initial diagnosis, and improved evidence-based treatment pathways to reduce incidence and severity by even small percentages would result in major financial savings and reduce the burden on patients.

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DATA AVAILABILITY STATEMENT

The data used in this study are available in the SAIL Databank at Swansea University, Swansea, UK, but as restrictions apply they are not publicly available. All proposals to use SAIL data are subject to review by an IGRP. Before any data can be accessed, approval must be given by the IGRP. The IGRP gives careful consideration to each project to ensure proper and appropriate use of SAIL data. When access has been granted, it is gained through a privacy-protecting safe haven and remote access system referred to as the SAIL Gateway. SAIL has established an application process to be followed by anyone who would like to access data via SAIL at https://www.saildatabank.com/application-process.

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REFERENCES

1. Burian EA, Karlsmark T, Franks PJ, et al. Cellulitis in chronic oedema of the lower leg: an international cross-sectional study. *BJD*. 2021;185:110-118. doi:10.1111/bjd.19803
2. Dupuy A, Benchikhi H, Roujeau JC, et al. Risk factors for erysipelas of the leg (cellulitis): case-control study. *BMJ*. 1999;318:1591.
3. Vignes A, Poizeau F, Dupuy A. Cellulitis risk factors for patients with primary or secondary lymphedema. *J Vasc Surg*. 2001;10(1):179-185.E1. doi:10.1016/j.jvsv.2021.04.009
4. Sapuła M, Krankowska D, Wiercińska-Drapało A. In search of risk factors for recurrent erysipelas and cellulitis of the lower limb: a cross-sectional study of epidemiological characteristics of patients hospitalized due to skin and soft-tissue infections. *Interdiscip Perspect Infect Dis*. 2020;2020:1307232.
5. Burian EA, Karlsmark T, Franks PJ, Keeley V, Quéré I, Moffatt CJ. Cellulitis in chronic oedema of the lower leg: an international cross-sectional study. *Br J Dermatol*. 2021;185(1):110-118.
6. Deng J, Fu MR, Armer JM, et al. Factors associated with reported infection and lymphedema symptoms among individuals with extremity lymphedema. *Rehabil Nurs*. 2015;40:310-319.
7. Vignes S, Dupuy A. Recurrence of lymphoedema-associated cellulitis (erysipelas) under prophylactic antibiotherapy: a retrospective cohort study. *J Eur Acad Dermatol Venereol*. 2006;20:818-822.
8. Chlebicki MP, Oh CC. Recurrent cellulitis: risk factors, etiology, pathogenesis and treatment. *Curr Infect Dis Rep*. 2014;16:422.
9. Al-Niaimi F, Cox N. cellulitis and lymphoedema: a vicious cycle. *J Lymphoed*. 2009;4(2):P38-P42. https://www.woundsinternational.com/uploads/resources/content_11173.pdf
10. NHS Digital. Hospital Admitted Patient Care Activity 2018–19. 2019.Available at: https://digital.nhs.uk/data-and-information/publications/statistical/hospital-admitted-patient-care-activity/2018-19.
11. SAIL Databank. https://saildatabank.com/.
12. Lyons RA, Jones KH, John G, et al. The SAIL databank: linking multiple health and social care datasets. *BMC Med Inform Decis Mak*. 2009;9:3. doi:10.1186/1472-6947-9-3
13. Ford DV, Jones KH, Verplancke JP, et al. The SAIL databank: building a national architecture for e-health research and evaluation. *BMC Health Services Res*. 2009;9:157. http://www.ncbi.nlm.nih.gov/pubmed/19732426
14. PEDW (Patient Episode data base Wales) data (19-20) down accessed Sept 2021. PEDW Data Online - Digital Health and Care Wales (nhs.wales).

15. BNF (British National Formulary). https://bnf.nice.org.uk/ Accessed October 2018.
16. Personal Social Service Research Unit (PSSRU 2017). http://www.pssru.ac.uk/project-pages/unit-costs/2017/. Accessed October 2018.
17. Financial Delivery Unit 2019/20 Welsh Health Board Annual Costing Returns as submitted to Welsh Government Parameters: Diagnosis Code L03 (cellulitis and acute lymphangitis) & HRG codes commencing 'JD' for 'skin disorder'.
18. NHS Wales Informatics Service. http://www.wales.nhs.uk/nwis/page/52552. Accessed October 2018.
19. Welsh Government (Statistics). https://gov.wales/statistics-and-research/welsh-index-multiple-deprivation/?lang=en. Accessed October 2018.
20. The Welsh Demographic Service Dataset (WDSD). https://nwis.nhs.wales/.
21. Hippisley-Cox J, Vinogradova Y Trends in Consultation Rates in General Practice 1995/1996 to 2008/2009. 2009. Analysis of the QResearch® database. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.518.744&rep=rep1&type=pdf.
22. Peterson RA, Polgreen LA, Cavanaugh JE, Polgreen PM. Increasing incidence, cost, and seasonality in patients hospitalized for cellulitis. *Open Forum Infect Dis*. 2017;4(1):ofx008. doi:10.1093/ofid/ofx008
23. Boettler MA, Kaffenberger BH, Chung CG. Cellulitis: a review of current practice guidelines and differentiation from Pseudocellulitis. *Am J Clinic Dermatol*. 2022;23(2):153-165.
24. Webb E, Neeman T, Bowden FJ, Gaida J, Mumford V, Bissett B. Compression therapy to prevent recurrent cellulitis of the leg. *N Engl J Med*. 2020;383(19):1891-1892.
25. Dalal A, Eskin-Schwartz M, Mimouni D, et al. Interventions for the prevention of recurrent erysipelas and cellulitis. *Cochrane Database Syst Rev*. 2017;6:CD009758.
26. Arsenault K, Rielly L, Wise H. Effects of complete decongestive therapy on the incidence rate of hospitalization for the management of recurrent cellulitis in adults with lymphedema. *Rehabil Oncol*. 2011;29(3):14-20.
27. Ellis Simonsen SM, van Orman ER, Hatch BE, et al. Cellulitis incidence in a defined population. *Epidemiol Infect*. 2006;134(2):293-299. doi:10.1017/S095026880500484X
28. Byford S, Torgerson DJ, Raftery J. Economic note: cost of illness studies. *BMJ*. 2000;320(7245):1335. doi:10.1136/bmj.320.7245.1335. PMID: 10807635; PMCID: PMC1127320.
29. Phillips CJ, Humphreys I, Fletcher J, Harding K, Chamberlain G, Macey S. Estimating the costs associated with the management of patients with chronic wounds using linked routine data. *Int Wound J*. 2016;13(6):1193-1197.
30. Phillips CJ, Humphreys I, Thayer D, et al. Cost of managing patients with venous leg ulcers. *Int Wound J*. 2020;17(4):869-1099.

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APPENDIX A

TABLE A1 Unit costs used in the analysis

GP costs	Unit cost (£)	Source
GP surgery visit (Per surgery consultation lasting 9.22 min)	£39	PSSRU 2020
GP home visit	£134	PSSRU 2013 (£114 inflated to 2020 prices using BOE calculator)
Practice nurse	£42	PSSRU 2020
GP telephone triage	£15.52	PSSRU 2020
Practice nurse telephone triage	£7.80	PSSRU 2020
District nurse	£88	PSSRU 2015 (£78 inflated to 2020 prices using BOE calculator)
Inpatient costs (Non-elective)	**Unit cost (£)**	**Source**
Mean daily In-patient costs	£416	Financial Delivery Unit 2019/20 Welsh Health Board Annual Costing Returns as submitted to Welsh Government Parameters: Diagnosis Code L03 (cellulitis and acute lymphangitis) & HRG codes for 'skin disorder'

TABLE A2 Clinical codes (ICD-10 codes in PEDW and read conditions codes in WLGP data)

Code list of ICD10 codes used to identify cellulitis in secondary care (PEDW) data	Modified read code list (conditions) for use in primary care (WLGP) events data
L03, cellulitis	M02z, cellulitis/abscess digit NOS (not otherwise specified)
L030, cellulitis of finger and toe	M036, cellulitis/abscess-leg ex. foot
L031, cellulitis of other parts of limb	M0363, cellulitis/abscess-lower leg
L032, cellulitis of face	M036z, cellulitis/abscess-leg NOS
L033, cellulitis of trunk	M03z, cellulitis/abscess NOS
L038, cellulitis of other sites	M03z0, cellulitis NOS
L039, cellulitis, unspecified	M08, Cutaneous cellulitis
	M085, cellulitis of leg
	M088, cellulitis of arm
	M08B, cellulitis of foot