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ORIGINAL RESEARCH ARTICLE

Gender-adjusted and age-adjusted economic inpatient burden of congestive heart failure: cost and disability-adjusted life-year analysis

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Abstract

Aims The two components of disability-adjusted life year (DALY), years of life lost (YLL) and years lived with disability (YLD), are underutilized in evaluating heart failure with reduced ejection fraction (HFrEF) and in assessing the global burden of disease. We aim to describe both the direct (medical) and the indirect (morbidity and mortality) inpatient cost of congestive heart failure in a high-income non-Organization for Economic Cooperation and Development Middle Eastern country in relation to YLL and YLD.

Methods and results We used the World Health Organization's global burden of disease methodology to calculate DALY, YLL, and YLD in 174 consecutive prospectively enrolled New York Heart Association Classes II–IV patients in a single-centre heart failure registry using a 0.4 disability weight and a 3% future age discount. We reported the cost of hospitalization, re-hospitalization, and non-invasive and invasive procedures per 1000 HFrEF patients in US dollars (USD). Expressing results as per 1000 HFrEF capita revealed a DALY of 1480 ± 1909 vs. 2177 ± 2547 in women and men, respectively. The costs per HFrEF capita in USD were \$909.00 ± 676.1 for a single-day hospital stay, \$7999 per single hospitalization, \$12 311 ± 13 840 for annual hospitalizations, \$20 486 ± 22 068 for all-cause hospitalizations, and \$37 355 ± 49 336 from the time of diagnosis until death or recovery.

Conclusions In this study, HFrEF imposed a substantial economic and disability burden on one non-Organization for Economic Cooperation and Development Middle Eastern country. However, men represented a higher economic burden than women.

Keywords DALY; Middle East; Congestive heart failure

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Introduction

The global prevalence of congestive heart failure (CHF), especially that of ischaemic aetiology, has increased since 1990 despite the fact that acute myocardial infarction incidence has decreased.[1] A total of 26 million people live with CHF worldwide, causing a significant strain on healthcare systems and national health expenditures.[2,3] CHF is responsible for 1–4% of all hospitalizations and up to 30% of readmissions within 30 days,[4] 2–17% of in-house mortality, up to 45% of 1 year mortality, and more than 50% of mortality within 5 years.[3,5] The average heart failure prevalence is 1–2% globally, as seen in Australia (1.3%), Japan (1%), China (1.3%), France (2.2%), Canada (1.5%), and the USA (1.9%).[3,6,7] A single-centred Middle Eastern study has reported a prevalence of 0.5% in Oman.[6] CHF consumes 1–3% of total health expenditures worldwide,[8] including €2.9bn in Germany for the year 2006 and \$20.9bn in the USA for 2012.[3,9] The initial admission annual cost in the USA is \$28bn, with a total cost of \$32bn each year including services, medications, and missed days of work.[10] Cardiovascular disease claims 17% of the USA's national health expenditure.[11]

Disability-adjusted life years (DALYs) were defined by C. J. Murray as indicators of non-fatal health outcomes and premature mortality,[12,13] whereas the World Health

Organization (WHO) has defined DALY as a health-gap measure of combined time lost due to morbidity and premature mortality.[2] The calculation for DALY uses disability weight (DW) as a proportional reduction of normal health on a scale of 0–100% disability.[1,13] Some reports have suggested DW ranges to be 0.037, 0.070, and 0.186 for mild, moderate, and severe CHF, respectively,[13–15] whereas Murray *et al*. have suggested the values of 0.43 and 0.39 for untreated and treated forms of CHF, respectively.[12] Several methods have been used to measure the impact of chronic diseases on population health expectancies and gaps, such as the calculation of quality-adjusted life years and DALY. The DALY calculation method used to measure the impact of chronic diseases on population health expectancies and gaps combines years of life lost (YLL) and years lived with disability (YLD) and multiplies the sum by a disease-specific DW. The heart failure with reduced ejection fraction (HFrEF) DW value ranges from 0.09 for slightly to 0.92 for severely limited ability to perform daily activities.[16]

In the Middle East, a literature review has revealed a 30 day mortality of 5.3–9%,[17] a questionable prevalence of 0.5%,[6,18] and an incidence of 54–71.7% for HFrEF compared with 19–46% for heart failure with preserved ejection fraction. A multinational trial with 2539 patients showed that CHF occurs at a younger age in the Middle East (63 ± 12) than in Latin America (68 ± 13).[6,19] The cardiovascular disease burden in Middle Eastern high-income non-Organization for Economic Cooperation and Development (OECD) countries is coded in the red world map zone and is equivalent to 4229–10 772 DALY per 100 000 persons.[20] Mortality has been reported at 191–541 per 100 000 men and 84–334 per 100 000 women.[20] Moreover, the North African/Middle Eastern DALY estimate for ischaemic heart disease, one of the main aetiologies of CHF, is 9 340 315 compared with 9 467 882 in Western Europe.[1]

Congestive heart failure disability is dynamic in nature, and patient condition changes from highly disabled during hospitalization to moderately disabled during an unplanned emergency room visit or mildly disabled during routine scheduled visits. Our methodology of using a fixed DW, although practical, accurate, and relevant, is not the most precise as a result of overgeneralization bias. On the other hand, reporting YLL and YLD in conjunction with cost per 1000 HFrEF population is feasible, requiring simple calculations, having a public domain tool provided by the WHO, and utilizing obtainable data compared with the DALY per 100 000 prevalence in the general population reporting approach. Moreover, we advocate that the ease of use of the YLL/YLD/cost per 1000 reporting approach may have a comparable benchmarking value at the regional or national level as a strategic map for balanced scorecard efficiency measures.

This study aims to shed light on the economic and disability burden of heart failure in a single centre in one high-income non-OECD Middle Eastern country, provide information for researchers to build on, and describe cost-related and disability-related gender variation. Measuring the burden of heart failure on the Middle East is of large economic relevance, as the per capita healthcare expenditure for HFrEF patients is more than six times the average per capita healthcare expenditure in high-income non-OECD Middle Eastern countries.[21,22]

Methods

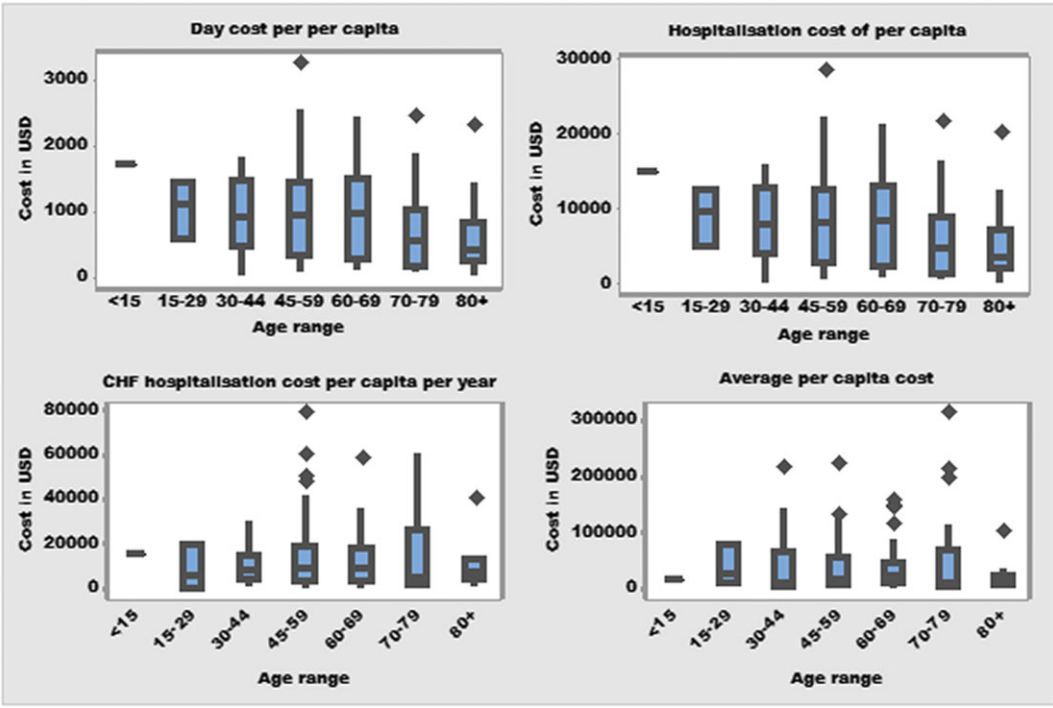
We used data from the Makkah heart failure database, a single-centred prospective registry of one of the largest government-funded tertiary centres in the western province of Saudi Arabia. We reviewed patient medical records to validate initial disease onset, length of stay, in-house mortality, and number of hospitalizations, re-hospitalizations, diagnostic angiograms, percutaneous coronary interventions, implantable cardiac defibrillators, and cardiac resynchronization therapy devices. We converted the cost value according to the 2015 exchange rate of 3.75 Saudi Riyal for 1 USD. We calculated YLL, YLD, and DALY using the formula *DALY = YLD + YLL* and adopted the WHO calculation methodology with a 3% future age discount.[15] Furthermore, we used a DW of 0.40 and hypothetical life expectancies of 80 and 82 years for men and women, respectively.[2,14,21,23] We have reported the results per 1000 capita of age-adjusted and gender-adjusted HFrEF patients.

Enrolled patients were New York Heart Association Classes II–IV, with an average age of 59.6 ± 12.9 years [confidence interval (CI): 57.7, 61.5], an average ejection fraction (EF) of 24.2 ± 10.3 (22.6, 25.7), an average atrial fibrillation history of 17% (CI: 0.124, 0.243), and an average ischaemic aetiology of 61% (CI: 0.53, 0.69). HFrEF patients had an average of 4.3 ± 3.7 hospitalizations since disease onset, 2.4 ± 1.5 all-cause hospitalizations, 1.5 ± 1.1 annual CHF hospitalizations, and 0.6 ± 0.9 annual CHF re-hospitalizations. Disease onset was defined as CHF hospitalization coinciding with echocardiographic evidence of EF <45. The average time from disease onset till death or recovery was 324.9 days ± 384.5 (CI = 266.7, 383.1), and patients required average health expenditures of $909 per day per hospital stay, $7999 per hospitalization, $12 311 for annual hospitalizations, $4943 per re-hospitalization, and $37 355 from disease onset per HFrEF patient (*Figure 1*).

Statistical analysis

We used Minitab Statistical Software v. 17 (2007, Pennsylvania, USA) for all statistical analyses.[24] A two-sample *t*-test was used to calculate the statistical significance for each group. We selected a *P* value of <0.05 and confidence level of $>95\%$ as the statistical significance cut-off points.

Figure 1 Cost distribution based on age group.



Results

Of the 174 consecutively enrolled patients in 2015 with New York Heart Association Classes II–IV CHF, 78% were men and 22% were women, with an average EF of 24%. Cost calculations, based on cash payments or insured patient payment schedules, revealed an average cost of $900 per direct hospitalization day, $220 per echocardiographic study, $3200 per diagnostic catheterization procedure, $3000 per additional stent placement, and $14 000 per device implantation. However, indirect costs of outpatient care, physical infrastructure use, and staff salaries were not accounted for. We added a 12% additional cost for patients who required coronary care unit admission based on a 12% HFrEF coronary care unit admission rate at the study facility.

Moreover, there was a total annual cost of $3 188 000 for device implantations, $1 692 000 for invasive angiographies, and $370 300 for echocardiographic non-

Table 1. The cost calculated per heart failure ($) with reduced ejection fraction capita for a single hospitalization day

Hospitalization cost per capita	*n* = 174 Mean ± SD (95% CI)	Per 1000 HFrEF capita
Hospitalization since disease onset	4.32 ± 3.6 (3.78, 4.85)	4316
Annual all-cause hospitalization	2.37 ± 1.5 (2.16, 2.61)	2379
Annual CHF hospitalization	1.51 ± 0.99 (1.36, 1.65)	1505.7
Annual CHF re-hospitalization	0.56 ± 0.92 (0.43, 0.70)	563.2
Annual single hospitalization cost	7999 ± 5950 (7109, 8889)	7 999 000
Hospital stay cost for a day	909.0 ± 676.1 (807.8, 1010.1)	909 000
Annual all cause hospitalization cost	20 486 ± 22 068 (17 184, 23 788)	20 486 000
Annual CHF hospitalization cost	12 311 ± 13 840 (10 241, 14 382)	12 311 000
Annual re-hospitalization cost	4943 ± 10 150 (3424, 6462)	4 943 000
Cost since disease onset	37 355 ± 49 336 (29 973, 44 737)	37 355 000
Annual diagnostic angiogram cost	1177 ± 1860 (899, 1455)	1 177 000
Annual invasive cost	1692 ± 2973 (1247, 2137)	1 692 000
Annual echocardiogram cost	370.3 ± 275.2 (329.1, 411.4)	370 300.00
Average annual device implantation cost	3188 ± 4897 (2455, 3920)	3 188 000.00
Single hospitalization	8.896 ± 9.529 (7.470, 10.322)	8896

CHF, congestive heart failure; CI, confidence interval; HFrEF, heart failure with reduced ejection fraction.

invasive procedures for HFrEF as calculated on a per 1000 capita basis (*Table 1*). Women had a statistically significant lower cost per day of hospitalization than men, at $708 (676) vs. $967 (667), $P = 0.039$, and for device implantation direct expenditure per capita, at $1368 ± 3613 vs. $3714 ± 5100, $P = 0.002$ (*Table 2*).

Compared with men, women had an older age at death, at 68.27 ± 14.30 (49.01, 87.53) vs. 60.87 ± 17.64 (43.65, 78.10). They also had more YLD, at 814 ± 1395 (−736, 2364) vs. 494 ± 482 (−84, 1071); fewer YLL, at 814 ± 1395 (−736, 2364) vs. 1683 ± 2533 (133, 3233); and fewer DALY, at 1480 ± 1909 (−237, 3197) vs. 2177 ± 2547 (460, 3894). However, these findings were not statistically significant (*Table 3*).

The current study provides a rough estimate of the burden of HFrEF in a high-income non-OECD Middle Eastern country and has shown that HFrEF patients have an average DALY measure of 1.1–2.3, 1.5 likelihood of being admitted to the hospital for CHF on an annual basis, and an average cost to the healthcare system of $12 311 annually for acute care hospitalization. Female HFrEF patients showed fewer YLL, at 1012, but more YLD and fewer total DALY per 1000 capita, indicative of a lower female economic burden compared with men. YLD in women were observed to peak in the age group of 70–79 years compared with those of both 60–69 and 70–79 years in men (*Figure 2*). We have observed a similar delayed total DALY peaking pattern in the 45–59 female age group compared with the 15–29 male age group (*Table 4*).

In this study, the per capita annual cost of HFrEF is $12 311, which represents 6 to 13 times the 2013 average per capita health expenditure of $808–$1569 in the Middle East.[21,22] Furthermore, compared with men, women had a unique trend of delayed disease onset, fewer YLL, longer survival, lower device implantation cost requirements, and fewer DALY per 1000 capita (*Figure 3*). This gender 'paradox' of female patients living longer and costing less may be partially explained by the more aggressive nature of the disease in men and the lower indication for device implantation.

Discussion

Previous works have shown that disability, mortality, and cost are commonly used to measure the global burden of many diseases.[25,26] The DALY methodology allows quantitative measurement of disability resulting from non-fatal disease and is thought of as one DALY being equal to 1 year lost to disability and/or mortality.[25] Our study has shown that the annual per capita health expenditure of $12 311 from direct CHF hospitalization is more than 10 times that of the per capita public health expenditure in this part of the world, and one CHF patient loses an average of 1.1–2.3 years as a result of premature death or disability. This condition adds significant socio-economic strain to healthcare system expenditures, requires efficient resource allocation to achieve an economical equity/efficiency balance, and may necessitate a mandate for international collaboration with large resourceful health organizations such as the WHO. The potential for international collaboration opportunities exists, as over the past decade the WHO has conducted various pilot country study initiatives for certain diseases.[27]

Table 2. Invasive procedure, diagnostic, and percutaneous coronary intervention for a single day of hospitalization

Annual cost per capita ($) (HFrEF patients)	Male (n = 135) Mean (SD)	Female (n = 39) Mean (SD)	P value (95% CI)
Diagnostic angiogram	1233 (1915)	985 (1667)	0.432 (−378, 874)
Invasive procedures and PCI	1754 (3021)	1477 (2829)	0.597 (−766, 1320)
Echocardiogram	368 (292)	377 (210)	0.826 (−92.8, 74.3)
Implantable device	3714 (5100)	1368 (3613)	0.002 (902, 3790)
Single hospitalization	8509 (5873)	6232 (5951)	0.039 (121, 4435)
Cost for a single-day hospital stay	967 (667)	708 (676)	0.039 (14, 504)

CI, confidence interval; HFrEF, heart failure with reduced ejection fraction; PCI, percutaneous coronary intervention.

Table 3. Years of life lost and years lived with disability results by gender

Items	Female	Male	P value (95% CI)
Death per 1000	49 ± 78.5 (−14.3, 113.7)	81.6 ± 89.8 (17.7, 145.6)	0.462
YLL per 1000	814 ± 1395 (−736, 2364)	1683 ± 2533 (133, 3233)	0.409
Hospitalization incidence per 1000	283 ± 387 (53, 514)	133.9 ± 184.9 (−96.2, 364.0)	0.341
YLD per 1000	666 ± 963 (89, 1244)	494 ± 482 (−84, 1071)	0.658
Age at onset	64.24 ± 6.18 (32.1, 96.4)	52.6 ± 27.5 (27.7, 77.5)	0.509
Age at death	68.27 ± 14.30 (49.1, 87.5)	60.87 ± 17.64 (43.65, 78.10)	0.52

HFrEF, heart failure with reduced ejection fraction; YLD, years lived with disability; YLL, years of life lost.
All values are represented as mean ± SD, confidence interval, and per 1000 HFrEF patients unless otherwise specified.

Figure 2 Age-adjusted and gender-adjusted years lived with disability.

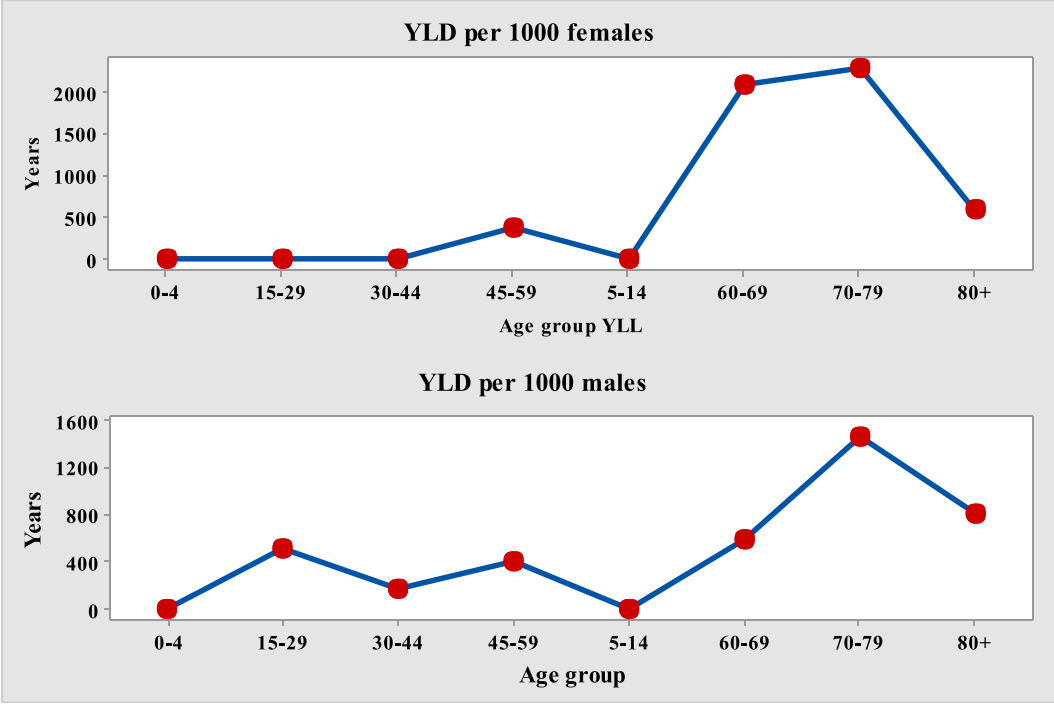


Table 4. Age-adjusted and gender-adjusted years of life lost and years lived with disability

Age group (years)	YLL (male)	YLL (female)	YLD (male)	YLD (female)	DALYs
0–4	0	0	0	0	0
5–14	0	0	0	0	0
15–29	7051	0	514	0	5043 ± 4367 (2603, 7484)
30–44	3912	0	181.4	0	2729 ± 2363 (288, 5170)
45–59	1366	3956	404.8	367	2797 ± 1348 (356, 5237)
60–69	0	1273	587.4	2088	1743 ± 1443 (−698, 4184)
70–79	438.1	1283	1458	2280	2637 ± 849 (196, 5078)
80+	699	0	804.1	595.3	1118 ± 469 (−1323, 3559)

DALYs, disability-adjusted life years; HFrEF, heart failure with reduced ejection fraction; YLD, years lived with disability; YLL, years of life lost.
All values are in mean ± SD, confidence interval, and per 1000 HFrEF patients unless otherwise specified.

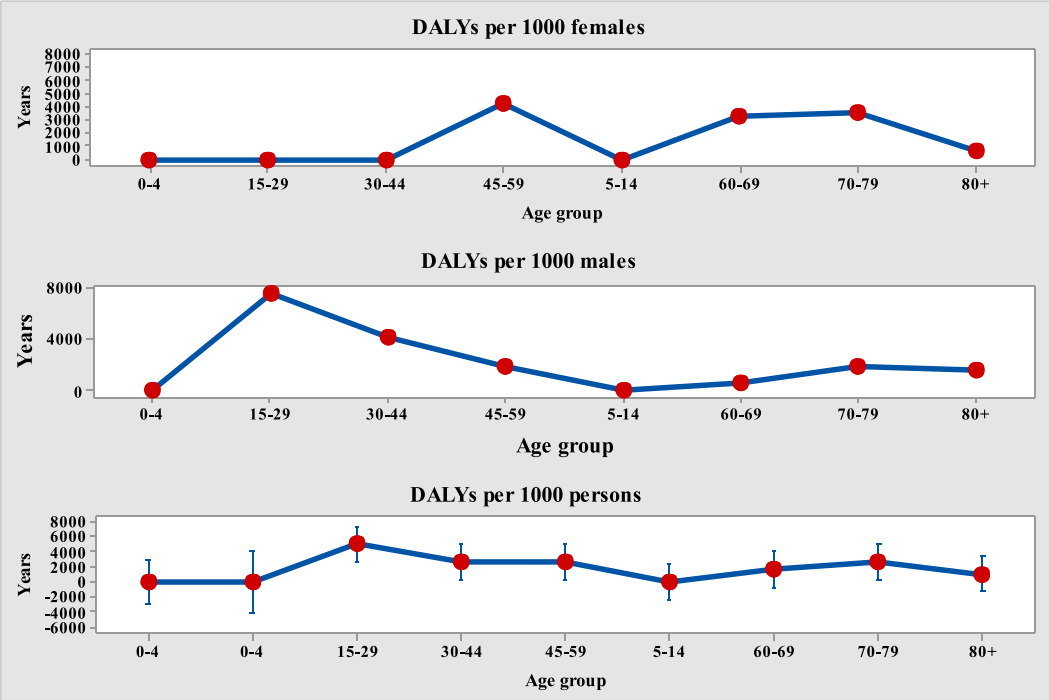
In our study, women lived longer with disability, died later, and cost less than men did. Device implantation cost was an important driver for such a cost discrepancy, as the average device implantation cost per male was $2000 higher than that per female (P = 0.002). These findings expose the need for technical and utilization efficiency reviews of device implantation in HFrEF patients. To a certain degree, our results may partially relate to results from Danish investigators published in the *New England Journal* in September 2016, which argued that prophylactic implantable cardioverter defibrillator implantation did not significantly improve mortality in patients with symptomatic HFrEF with no or mild coronary artery disease.[28]

Strengths and limitations

In the Middle East, few studies are published on the burden of heart failure, and this study might be the first to combine the DALY methodology with a health spending analysis in a Middle Eastern population sample. Considering the minimal research resources used and the lack of international organizational sponsorship, this study could be viewed as a pilot research proposal for larger national or regional studies in the future.

This study was limited by the unavailability of validated input data for age adjustment, life expectancy estimation, and standardized DW metrics. Additionally, this study is single

Figure 3 Disability-adjusted life years based on gender and individual. DALYs, disability-adjusted life years.



centred and has used a DALY estimation per 1000 capita for the disease subgroup of HFrEF rather than for the general population. No social weighting was performed with the DALY calculation or for costs of direct hospitalization. Also, the single-centre data obtained for this study may not reflect the reality of the country. In addition, outpatient care, physical infrastructure use, staff salaries, patient days off work, and dependents' loss of income were not included. However, reporting heart failure per 1000 patient units may function as a guide for researchers and policymakers.

Conclusions

Congestive heart failure's enormous strain on healthcare expenditures necessitates a global call for action for international collaboration, aiming for equity of care and efficiency of service provision.

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Conflict of interest

None declared.

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