Peak Winter! A Report on the Seasonal Impact of Heart Failure in Australia!

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1. EXECUTIVE SUMMARY

Based on the best available evidence, this Report describes the annual burden of hospital admissions linked to a primary diagnosis of Cardiovascular Disease (CVD) and Heart Failure through the prism of *Seasonality*. On this basis, we describe the differential burden of disease across Australia according to the four distinct seasons that most Australians are exposed to. Our key findings are as follows:

- Despite living on a continent where icy conditions and snow are rare, paradoxically, Australians are vulnerable to weather extremes; particularly exposure to Winter weather conditions.
- Although almost ***every Australian is at risk of experiencing Seasonality***, key contributors to this phenomenon are poor lifestyle choices, pre-existing CVD, older age, exposure to climate extremes and/or high levels of pollution and fewer economic resources to maintain thermoregulatory control.
- Compared to lower levels of hospitalisation during Summer, overall, there is a ***32% increase*** in the number of hospital admissions linked to CVD and Heart Failure during Winter.
- On this basis, among the estimated 593,000 admissions for CVD in Australia in 2019, ***41,500 (>450 per day) more CVD admissions will occur in Winter than in Summer.***
- A key contributor to this *Winter Peak* is Heart Failure. Of 73,500 admissions linked to a primary diagnosis of Heart Failure in 2019, ***5,200 (~60 per day) more admissions will occur in Winter than in Summer***.
- Overall, when considering the excess number of admissions occurring in Autumn, Winter and Spring combined compared to Summer, *Seasonality* resulted in ***71,000 more CVD admissions at a cost of $360 million.***
- Similarly, when considering the excess number of admissions occurring in Autumn, Winter and Spring combined compared to Summer, *Seasonality* resulted in ***8,800 more Heart Failure admissions at a cost of $204 million per annum***.
- Given that *Seasonality* is also a major contributor to premature mortality in those affected by Heart Failure (up to 10% of patients die within 30-days of admission), in addition to significant cost-savings, **hundreds of lives will also be saved each year** by preventing this deadly phenomenon.
- On a regional basis, ***individuals living in South Australia and Tasmania are at particular risk of Seasonality***. However, so are individuals living in the milder climes of Queensland.
- By 2030, the total number of CVD-related admissions will have risen to 645,000. Of these, ***an additional 45,000 will occur in Winter compared to Summer of 2030***.
- Without action, every State and Territory in Australia will experience a rise in the burden of Heart Failure and an increasing burden imposed by *Seasonality*; but this will vary. For example, ***in South Australia by 2030 the number of Heart Failure admissions will have increased (in absolute terms) by 8.2% and the Winter Peak by 9.8%***. In NSW, the equivalent figures will be 8.6% and 9.9%, respectively.

2. PURPOSE OF THIS REPORT

Over the past few years, we, along with our national and international partners, have closely examined why, despite the development and application of evidence-based, hospital avoidance programs, the demand for emergency hospital services in Australia is steadily increasing.[1]

As will be explained in more detail below, we have identified the phenomenon of *Seasonality* as major, predictable but often under-appreciated contributor to the burden imposed by CVD, given that it – **a)** provokes costly and potentially deadly clinical events in vulnerable individuals; and **b)** places enormous pressure on finite health resources at certain times of year.

As we experience another deadly Winter season in Australia, the main purposes of this Report, therefore, are three-fold:

1. Highlight and explain the issue of *Seasonality* from a population to individual level perspective, as a matter of urgent public health importance; *dispelling any myths that on such a warm continent, we might not be exposed to the risk of cold weather events*.
2. Translate the one-dimensional figures typically used to describe the burden of any disease (e.g. number of related admissions per year) into a more dynamic picture of seasonal ebbs and flows in hospital admissions across the country; *with a particular focus on its impact on the pattern of hospital admissions among vulnerable individuals affected by the potentially deadly and disabling condition Heart Failure*.
3. Outline the ongoing costs and consequences of not adequately responding to a phenomenon that will only be exacerbated by current and predicted climate change [2]; *noting the likely increase in those susceptible to Seasonality due to the progressing ageing of the population in whom the risk of developing Heart Failure remains high*.

In generating the key facts and figures contained within this Report, we've endeavoured to apply the best available data and evidence. However, as will be reaffirmed in the **Limitations** section, there are many aspects around the burden and impact of both Heart Failure and *Seasonality* that require future clarification and research. At the very least, we hope this deliberately provocative Report will stimulate an interest among the public and health professionals alike, in a phenomenon that, paradoxically, is just as likely to occur in the warm and temperate climes of Australia, as it is in the wintry climes of Scandinavia!

3. KEY DEFINITIONS

In compiling this Report, we refer to the following key terms:

Cardiovascular Disease (CVD): refers to all diseases affecting the heart and blood vessels supplying vital organs such as the brain and kidneys. The most common manifestations of CVD include - **a**) Coronary Artery Disease leading to an acute myocardial infarction or acute coronary syndrome ("heart attack"); **b**) Atrial Fibrillation (a fast and chaotic heart-beat); **c)** Stroke/Cerebrovascular Disease (the equivalent of a heart attack affecting the blood supply to the brain); and, the focus of this report; and **d**) Heart Failure.

Heart Failure: rather than being a distinct diagnosis or medical condition, Heart Failure refers to a syndrome where the heart is unable to either contract or relax properly; leading to insufficient blood supply to vital organs (including the lungs, kidneys and brain), counter-productive changes to the heart and blood vessels and, subsequently, poor quality of life, frequent hospital admissions and even premature death. The most common causes of Heart Failure are long-term damage to the heart and blood vessels due to uncontrolled high blood pressure (Hypertension) and the most common forms of CVD outlined above. The risk of developing Heart Failure increases markedly with age and is commonly described as affecting one in ten people aged over the age of 65 years. It is the most common form of chronic heart disease in Australia. [3]

Seasonality: this key term refers to the distinctive and repeated ebbs and flows in the rate of CVD-related events (most notably hospital admissions and deaths among vulnerable individuals) according to the changing seasons and climatic/weather conditions. According to our definition and the framework of this report, *Seasonality* also refers to the sudden spike in hospital admissions and deaths during acute weather events (e.g. an unseasonal cold-snap or particularly intense heatwave). [4] As will be noted later in the Report (particularly in respect to the Northern Territory), *Seasonality* is most notable in "four-season" climates with distinctive Winters and Summers. [4] However, it is also evident in the typically dichotomous (dry/wet) seasons found in tropical/sub-tropical regions. [5]

Winter Peaks: despite the understandable focus on heat waves within the context of climate change, the most distinctive and common manifestation of *Seasonality* in Australia and worldwide is a sustained increase in CVD-related admissions and deaths during the winter months. [4,6,7] The extent of *Winter Peaks* is best measured/understood by dividing the total number of events occurring each year and then assuming that they would randomly occur in any month or season; creating a steady average across each season. The opposite to *Winter Peaks* is *Summer Troughs* in CVD-related events.

4. CARDIOVASCULAR SEASONALITY: A GLOBAL PHENOMENON

As depicted in **Figure 1**, the phenomenon of *Seasonality* influencing the pattern of CVD-related events has been found and documented across the globe.[4] This includes reports from Australia.[6,7]

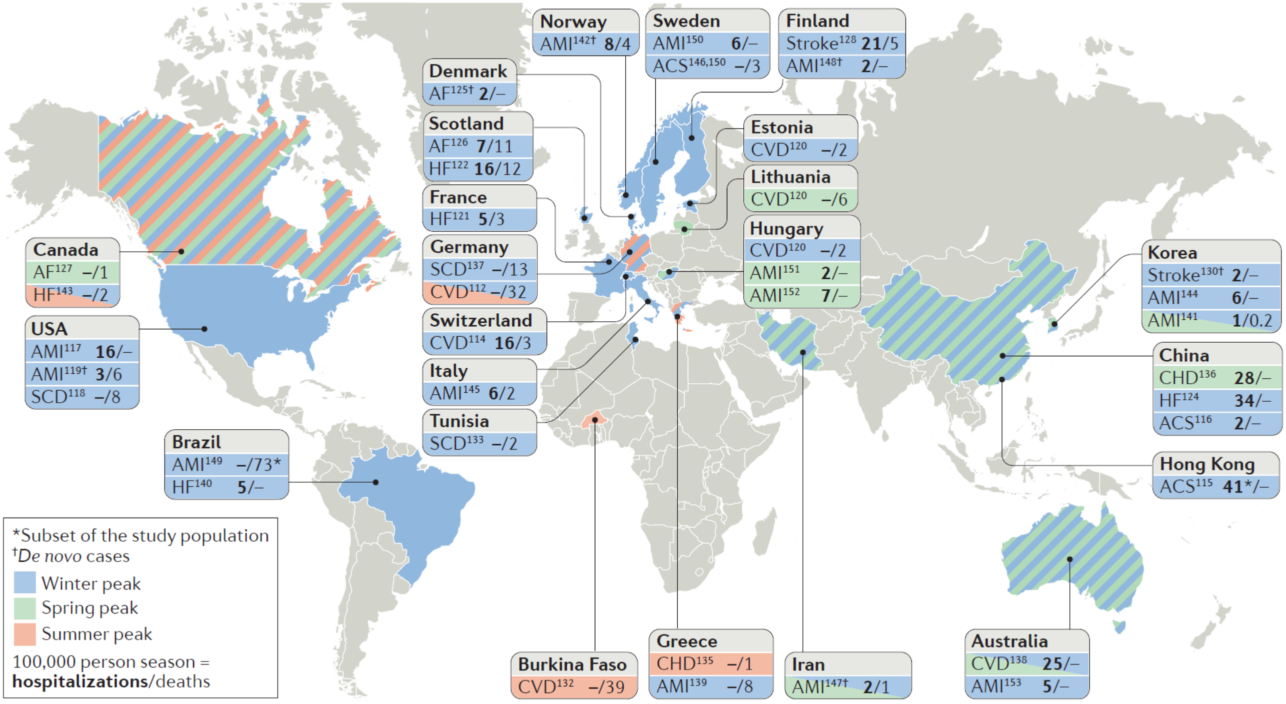


Figure 2 | **Absolute difference in seasonal peak versus trough rates of cardiovascular events across the globe.** Findings from large epidemiological studies examining seasonal variations in cardiovascular disease (CVD)-related hospitalizations and deaths, providing like-for-like, global comparisons in terms of variance of event rates (from peak to trough periods per 100,000 population at risk of event per annum) across a range of CVD subtypes. Overall, these data show a predominance of winter peaks across a range of CVD subtypes, but with some spring and summer peaks in event rates linked to acute myocardial infarction (AMI) in particular. ACS, acute coronary syndrome; AF, atrial fibrillation; CHD, coronary heart disease; HF, heart failure; SCD, sudden cardiac death.

FIGURE 1. The Global Phenomenon of Cardiovascular Seasonality: Reprinted from Stewart S, et al. Nature Reviews Cardiology (2017) [4]

The major feature of this phenomenon is the predictable increase in hospital admissions and deaths linked to all-forms of CVD, including Heart Failure, during winter months (*Winter Peaks*) or shortly thereafter in early Spring. Remarkably, *Seasonality* is just as likely to be reported in warmer climates with mild winters as colder climates with extremely cold (and dark) winters; with some evidence to suggest that there is a greater difference between *Winter Peaks* and *Summer Troughs* in event rates in milder climates.[4] To understand this phenomenon, we have previously examined the causes and consequences of *Seasonality* from an individual perspective rather than as an epidemiological curiosity.[8]

5. SEASONALITY IN CVD: INDIVIDUAL VULNERABILITY TO RESILIENCE

In carefully considering the reasons why the burden of CVD (particularly *Winter Peaks*) continues to rise despite the application of evidence-based hospital avoidance program (including those developed by us focussed on improving outcomes for those affected by chronic heart disease including Heart Failure [9]), we have developed a unique and holistic model of *Seasonal Vulnerability* in those at risk of, or with clinically diagnosed CVD.[8] As shown in **Figure 2**, for the first-time, this model shows how a combination of factors determine an individual's level of "resilience" to *Seasonality*. Two critical points are highly relevant to this report –

1) In most cases, individuals with Heart Failure are already compromised/vulnerable to *Seasonality* due a combination of their age, extent of disease and risk behaviours that led to them developing the syndrome and;

2) The paradox of *Seasonality* in countries like Australia, makes perfect sense when one considers that societies and individuals located in very cold countries are likely to be highly adapted (from a physiological, cultural and public health policy perspective) to the provocation of temperature and weather extremes. Alternatively, while Australians routinely adapt to hot weather/heat waves, they are far less prepared for the provocation of Winter and relatively cooler temperatures.

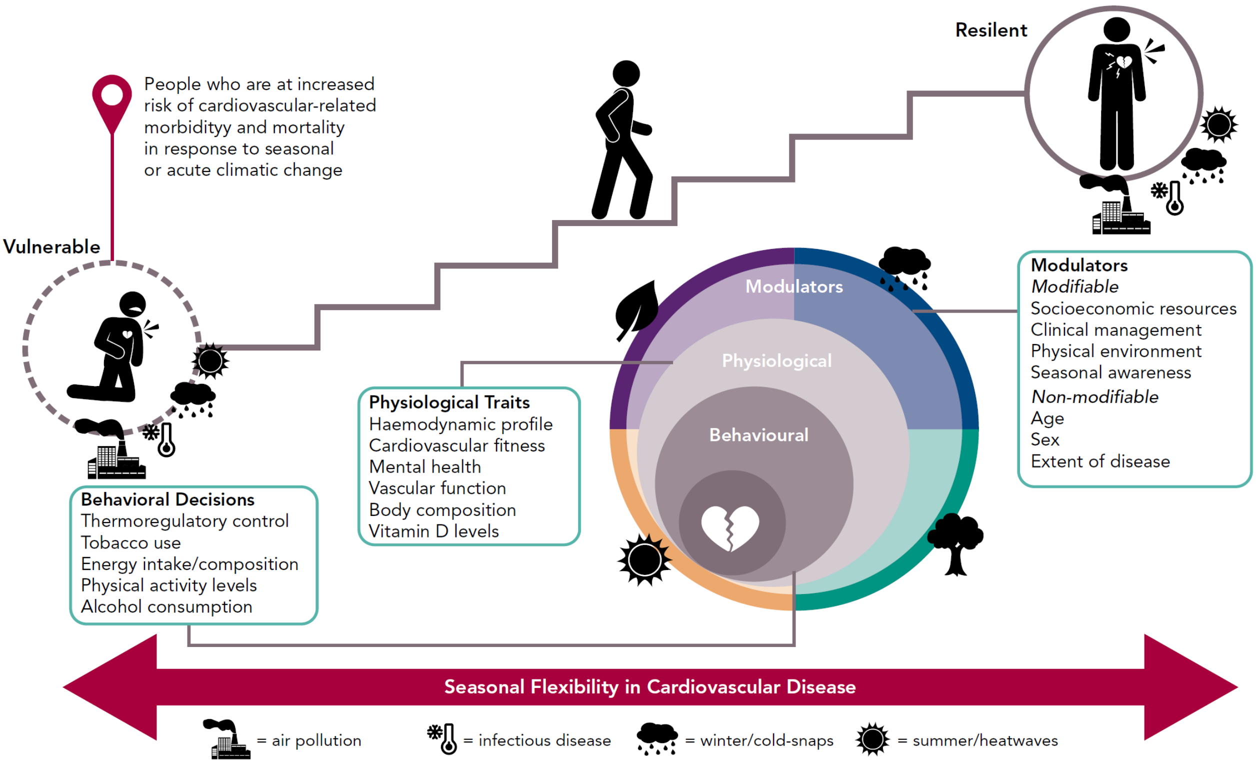


FIGURE 2. A Bio-Behavioural Model of Seasonality in CVD: Reprinted from Stewart S, et al. Cardiac Failure Review (2019) [8]

6. SEASONAL FREQUENT FLYERS IN AUSTRALIA

To properly test our model of *Seasonal Vulnerability*, it was important for us to demonstrate that a pattern of *Seasonality* is evident even in those individuals with chronic heart disease (including Heart Failure) exposed to gold-standard pharmacological and device-based therapies, in addition to expert management designed to reduce readmissions to hospital and prolong survival.[3] **Figure 3** shows that in such individuals (who would be theoretically "resistant" to *Seasonality*), this phenomenon was evident; a clear *Winter Peak* in hospital admissions accompanied by a *Spring Peak* in subsequent deaths.[10]

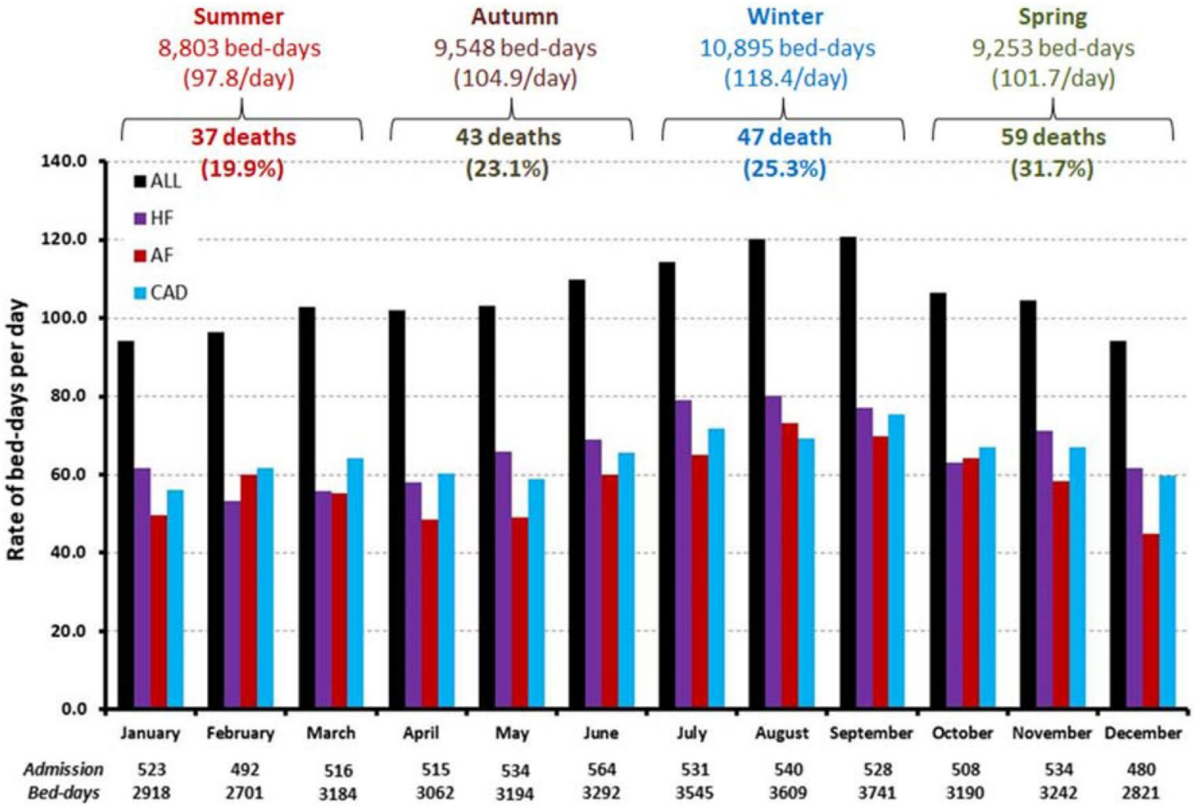


FIGURE 3. A Pattern of Seasonality in 1598 Individuals with Chronic Heart Disease in Australia: Reprinted from Loader J, et al. International Journal of Cardiology (2019) [10]

In collaboration with Professor John McMurray and his team from the University of Glasgow, we have since confirmed our findings (currently unpublished) in >15,000 individuals with Heart Failure participating in two of the largest clinical trials of new pharmacological agents (the ATMOSPHERE AND PARADIGM Trials). These individuals were closely followed-up and expertly managed within a range of climates (from Continental North America to South Africa) and the same pattern of *Seasonality* described above remained evident.

7. METHODS

To conservatively quantify the pattern of *Seasonality* influencing the pattern of hospital admissions due to Heart Failure in Australia with increasing granularity, we have combined data from –

a) The Australian Institute of Health and Welfare (AIHW) describing the age and sex-specific rate of hospitalisations linked to the most recognisable and diagnosable form of Heart Failure (noting a large burden of this syndrome largely affecting older women is not considered in this report); [11]

b) Population data published by the Australian Bureau of Statistics (ABS); [12] and

c) A consistent pattern of *Seasonality* documented by us in relation to Heart Failure. [10]

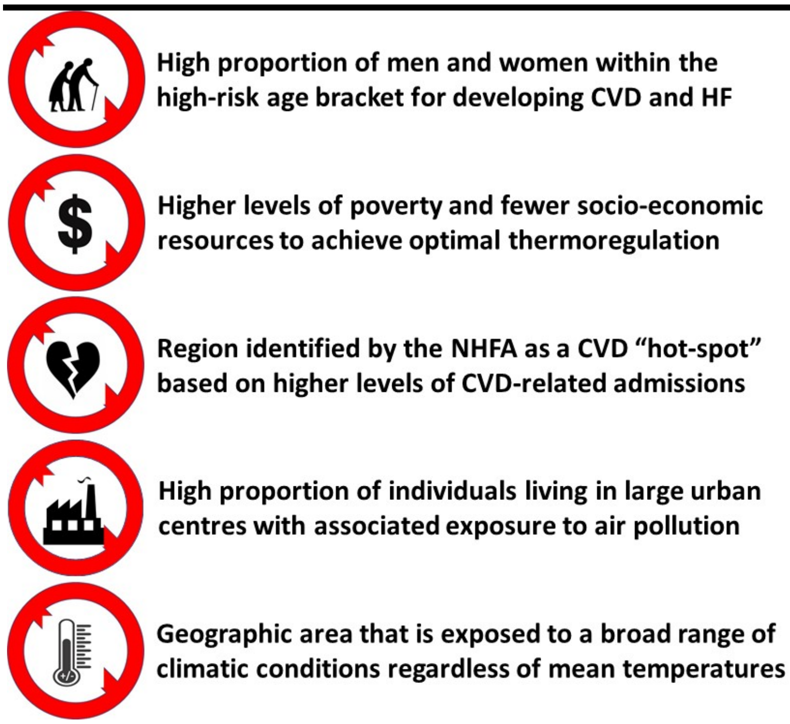
The broad framework of this methodology has been applied previously to generate a number of burden of disease reports in respect to describing and predicting the pattern of chronic heart disease here in Australia; [13] having been validated and employed previously in the United Kingdom.[14] **Table 1** outlines the key components used to describe the context of our findings and the data specifically relating to the burden of Heart Failure hospital admissions how it ebbs and flows on a seasonal basis.

TABLE 1. Key Components of this Report

Key Parameter(s)	**Description**
Climate Classification	Each region of interest is described from a climatic/weather perspective using the Köppen Climate Classification system.[15] For example, this gold-standard system shows Melbourne has a relatively "mild" and distinctive *Marine West Coast Climate* (mean temperature, 14°C; range, 9-20°C).
Geographic Regions/ Populations	For this Report, we have specifically focussed (in order of priority) on describing the burden and seasonal pattern of Heart Failure admissions in Australia overall, the six major states with large populations exposed to distinctive seasonal changes (*noting our special notes in relation to the Northern Territory and tropical regions of Queensland and Western Australia*) and then examples of distinctive populations within each of these states (plus the Australian Capital Territory) with varying levels of risk of *Seasonality*.
Age & Sex Demographics	ABS data on the estimated demographic structure of the overall Australian population and for each state according to sex and in 10-year age groups above the age of 25 years for the year 2018 were used.[12] These same demographic data were then examined with increasing granularity (smaller areas) using data derived from the 2016 Census. The ABS also publish data on the projected population of Australia for the foreseeable future. In order to conservatively estimate the burden of Heart Failure in the next 5-10 years, we used the same population data for the years 2025 and 2030 – see *Appendix*.
CVD & HF Admissions	The AIHW have published data on the age and sex-specific rate of CVD and Heart Failure-related admissions for the period 2015-2016; these rates were combined with ABS population data for Australia and the smaller jurisdictional/geographic areas of interest for the year 2018 in addition to the

	years 2025 and 2030 for future projections of Heart Failure-related admissions – see *Appendix*.[11]
Seasonality	The following seasonal distribution of total Heart Failure admissions per annum (derived from the combination of AIHW and ABS data were applied); noting the upper and lower estimates in parentheses used to derive a sensitivity analysis of the respective lowest versus highest differences between *Winter Peaks* and *Summer Troughs* in Heart Failure admissions: **SUMMER**: **22%** (22% vs. 23%) of the annual total of Heart Failure admissions. **AUTUMN**: **25%** (24% vs. 27%) **WINTER**: **29%** (28% vs. 30%) **SPRING**: **24%** (23% vs. 26%) NB. If *Seasonality* was not influential in determining clinical stability, the random distribution of clinical events would result in 25% of admissions (with only minor variations) occurring in each of the four seasons.

Regional Vulnerability: As noted in our model of *Seasonal Vulnerability* (**Figure 2**), several largely non-modifiable (but not exclusively so) factors will contribute to an increased signal of *Seasonality* in those affected by CVD and particularly HF. Many of these same factors can be assessed at the population level to assess the vulnerability of whole regions to higher levels of *Seasonality* and, therefore, *Winter Peaks* resulting in typical manifestations of high health service demands and resulting dysfunction/stress (including ambulance ramping, bed-block and cancellation of elective procedures/admissions). It is on this basis that we've created a 5-Point rating system to evaluate the potential for higher-levels of *Seasonality* in each geographic region of interest.



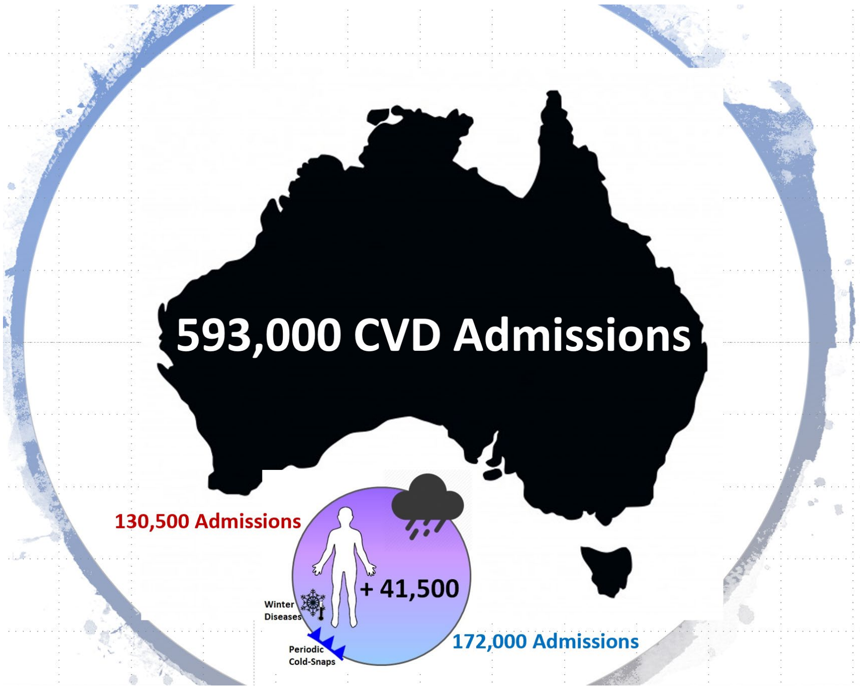
To determine if one of these five symbols be applied, we compared: **1**) ABS population data from a regional to whole Australian perspective; **2**) Contemporary data on the indices of socio-economic wealth across jurisdictions;[16-18] **3**) The National Heart Foundation of Australia's (NHFA) "hot-spot" report on CVD admissions;[19] **4**) The pattern of urban and rural dwelling communities on a regional basis; and **5**) The predominant range of climatic conditions affecting each geographic area.[20] Although we are unable, at this point, to determine the relative influence of each of these five factors, it is clear that the more symbols allocated, the higher the risk of *Seasonality*!

FIGURE 4. **A "5-Point" System for Evaluating the Likely Extent of Seasonality in Different Regions**

8. OUR FINDINGS

8.1 CVD ADMISSIONS AND SEASONALITY IN AUSTRALIA

Based on the current population profile of Australia and data provided by the AIHW, in 2019, the Australian health care system will contend with close to 600,000 hospital admissions linked to CVD; with a predominance of male admissions. As shown in **Figure 5**, the projected difference between Winter Peak versus Summer Trough hospital activity will be ***>40,000 admissions nationally***; a 32% absolute difference in hospital admissions between these two seasons. Based on our *sensitivity analyses*, this figure may be as high as ***47,500*** (36% difference) or as low as ***36,000*** (28% difference). Furthermore, when comparing the pattern of admissions in Summer (markedly lower than every other season) we estimate that in 2019, ***Seasonality will contribute to an additional 71,000 more admissions due to CVD in Autumn, Winter and Spring, combined***.



	CVD Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	6,555	1,442	1,442	1,508	1,639	1,573	1,770	1,901	1,835	1,966	1,573	1,508	1,704
25–34 years	5,772	1,270	1,270	1,328	1,443	1,385	1,559	1,674	1,616	1,732	1,385	1,328	1,501
35–44 years	13,191	2,902	2,902	3,034	3,298	3,166	3,561	3,825	3,693	3,957	3,166	3,034	3,430
45–54 years	32,734	7,201	7,201	7,529	8,183	7,856	8,838	9,493	9,165	9,820	7,856	7,529	8,511
55–64 years	64,305	14,147	14,147	14,790	16,076	15,433	17,362	18,648	18,005	19,291	15,433	14,790	16,719
65–74 years	97,206	21,385	21,385	22,357	24,301	23,329	26,246	28,190	27,218	29,162	23,329	22,357	25,273
75–84 years	85,746	18,864	18,864	19,722	21,436	20,579	23,151	24,866	24,009	25,724	20,579	19,722	22,294
85+ years	41,155	9,054	9,054	9,466	10,289	9,877	11,112	11,935	11,523	12,347	9,877	9,466	10,700
ALL MALES	346,662	76,266	76,266	79,732	86,666	83,199	93,599	100,532	97,065	103,999	83,199	79,732	90,132
	CVD Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	5,562	1,224	1,224	1,279	1,390	1,335	1,502	1,613	1,557	1,668	1,335	1,279	1,446
25–34 years	5,803	1,277	1,277	1,335	1,451	1,393	1,567	1,683	1,625	1,741	1,393	1,335	1,509
35–44 years	10,991	2,418	2,418	2,528	2,748	2,638	2,968	3,187	3,078	3,297	2,638	2,528	2,858
45–54 years	19,316	4,250	4,250	4,443	4,829	4,636	5,215	5,602	5,408	5,795	4,636	4,443	5,022
55–64 years	33,300	7,326	7,326	7,659	8,325	7,992	8,991	9,657	9,324	9,990	7,992	7,659	8,658
65–74 years	55,351	12,177	12,177	12,731	13,838	13,284	14,945	16,052	15,498	16,605	13,284	12,731	14,391
75–84 years	65,748	14,465	14,465	15,122	16,437	15,779	17,752	19,067	18,409	19,724	15,779	15,122	17,094
85+ years	50,515	11,113	11,113	11,618	12,629	12,124	13,639	14,649	14,144	15,155	12,124	11,618	13,134
ALL FEMALES	246,585	54,249	54,249	56,715	61,646	59,181	66,578	71,510	69,044	73,976	59,181	56,715	64,112

FIGURE 5. Annual Burden and Seasonal Pattern of CVD-Related Admissions in Australia

Figure 6 shows the dynamic contribution of older Australians (particularly men aged 65-74 years and women aged 75-84 years) to the overall burden of disease imposed by CVD. It also shows the extent of seasonal differences in the pattern of CVD-related admissions among Australian men and women. Such data are critical to understanding the future threat of an increasing burden of CVD and, more specifically Heart Failure, within Australia's progressively ageing population; particularly given early reports from the United Kingdom that, as predicted in a previous Australian report,[21] declining rates of CVD have now started to reverse due to sedentary and unhealth lifestyle behaviours.[22]

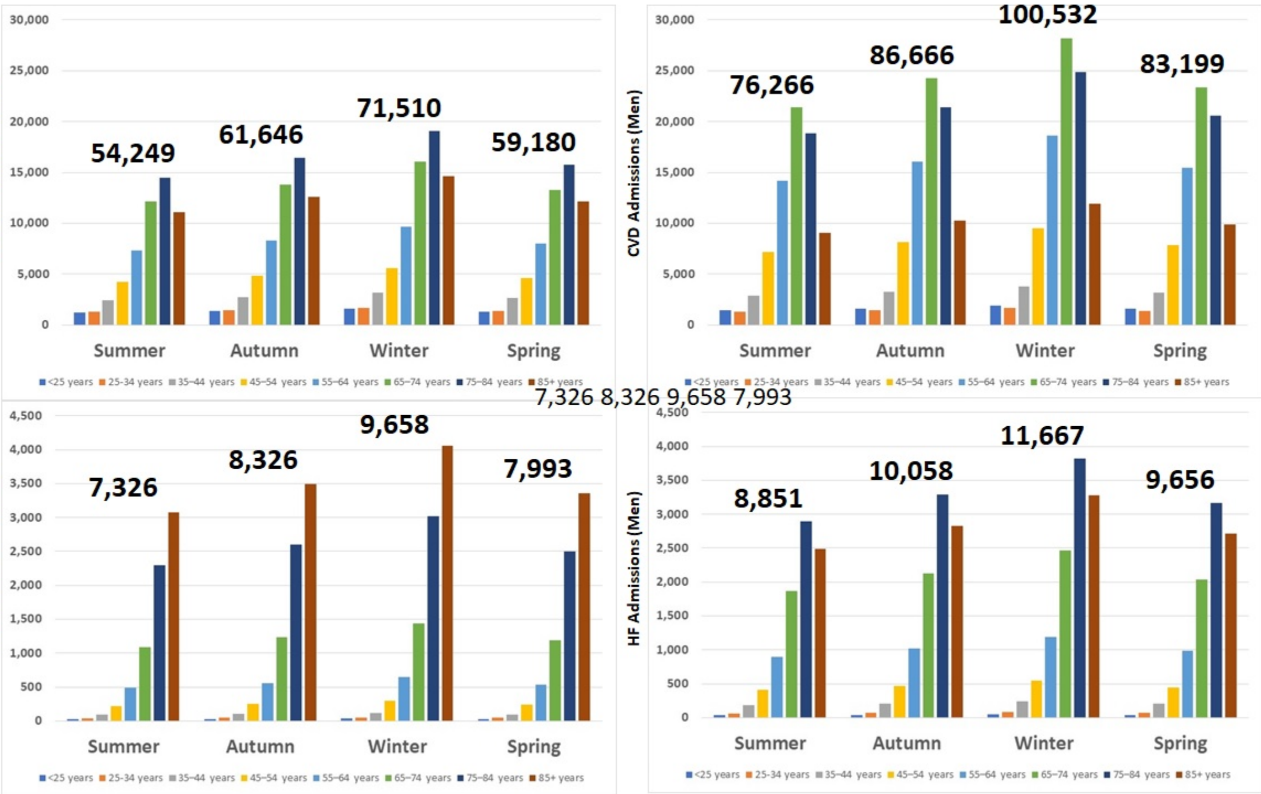
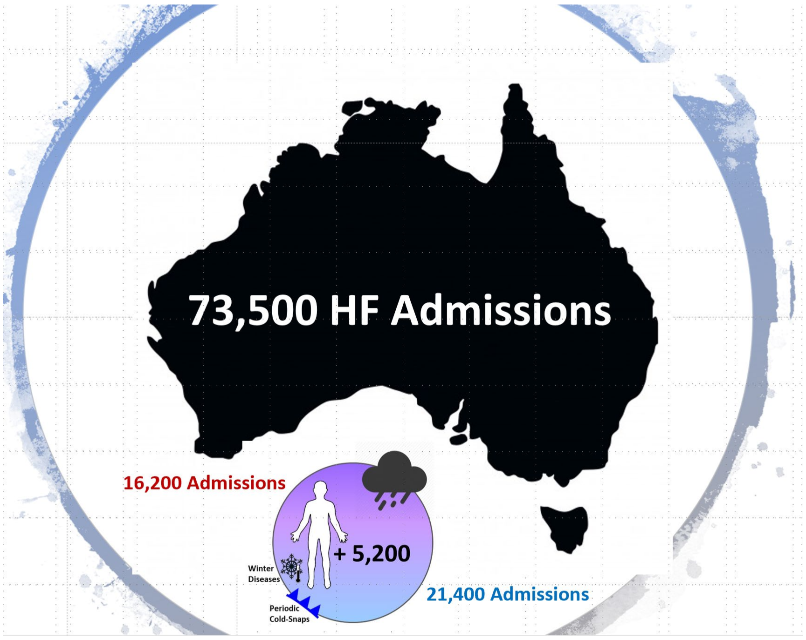


FIGURE 6. **Age and Sex-Specific Burden and Seasonal Pattern of CVD and Heart Failure (HF)-Related Admissions in Australia**

8.2 HEART FAILURE ADMISSIONS AND SEASONALITY IN AUSTRALIA

Based on the current population profile of Australia and data provided by the AIHW, in 2019, the Australian health care system will contend with ***>70,000 hospital admissions*** where Heart Failure is reported as the primary cause of that admission. As noted in a previous report, given that the syndrome is a major contributor to at least the same number of hospital admissions where it is listed as a secondary diagnosis, the total number of Heart Failure-related hospital admissions is more likely 150,000. [13] As shown in **Figure 7**, the projected difference between *Winter Peak* versus *Summer Trough* hospital activity associated with a primary diagnosis of HF, will be ***>5,000 admissions*** nationally. Once again, this represents a 32% increase in hospital activity in Winter compared to Summer. Based on our *sensitivity analyses*, this figure may be as high as ***5,900*** (36%) or as low as ***4,400*** (27%). Furthermore, when comparing the pattern of admissions in Summer (markedly lower than every other season) we estimate that in 2019, ***Seasonality will contribute to an additional 8,800 more admissions due to Heart Failure in Autumn, Winter and Spring, combined***.



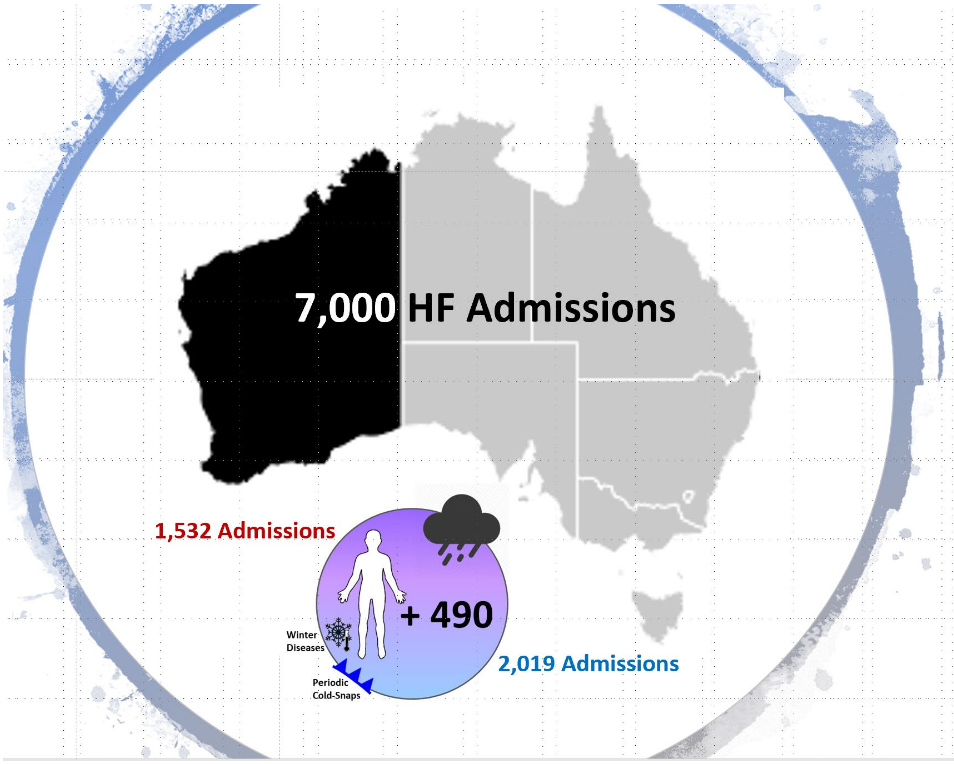
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	163	36	36	37	41	39	44	47	46	49	39	37	42
25–34 years	279	61	61	64	70	67	75	81	78	84	67	64	73
35–44 years	842	185	185	194	210	202	227	244	236	253	202	194	219
45–54 years	1,866	411	411	429	467	448	504	541	523	560	448	429	485
55–64 years	4,093	900	900	941	1,023	982	1,105	1,187	1,146	1,228	982	941	1,064
65–74 years	8,491	1,868	1,868	1,953	2,123	2,038	2,293	2,462	2,377	2,547	2,038	1,953	2,208
75–84 years	13,180	2,900	2,900	3,031	3,295	3,163	3,559	3,822	3,690	3,954	3,163	3,031	3,427
85+ years	11,317	2,490	2,490	2,603	2,829	2,716	3,056	3,282	3,169	3,395	2,716	2,603	2,943
ALL MALES	40,232	8,851	8,851	9,253	10,058	9,656	10,863	11,667	11,265	12,070	9,656	9,253	10,460
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	116	25	25	27	29	28	31	34	32	35	28	27	30
25–34 years	188	41	41	43	47	45	51	54	53	56	45	43	49
35–44 years	416	92	92	96	104	100	112	121	117	125	100	96	108
45–54 years	1,011	223	223	233	253	243	273	293	283	303	243	233	263
55–64 years	2,216	488	488	510	554	532	598	643	620	665	532	510	576
65–74 years	4,960	1,091	1,091	1,141	1,240	1,190	1,339	1,438	1,389	1,488	1,190	1,141	1,290
75–84 years	10,421	2,293	2,293	2,397	2,605	2,501	2,814	3,022	2,918	3,126	2,501	2,397	2,710
85+ years	13,974	3,074	3,074	3,214	3,493	3,354	3,773	4,052	3,913	4,192	3,354	3,214	3,633
ALL FEMALES	33,302	7,326	7,326	7,659	8,326	7,993	8,992	9,658	9,325	9,991	7,993	7,659	8,659

FIGURE 7. Annual Burden and Seasonal Pattern of Heart Failure (HF)-Related Admissions in Australia

8.3 HEART FAILURE ADMISSIONS AND SEASONALITY IN WESTERN AUSTRALIA

Western Australia (Mediterranean/Hot Desert Climate)

The climate in the major population centre of Perth is warm and temperate; classified as **Csa** by Köppen and Geiger. The average annual temperature is ~19 °C and the annual average rainfall is ~800 mm. The driest month is January (7 mm of rain) compared to June (average rainfall of 175 mm). February is the warmest month of the year (average temperature ~25 °C) and July is the coldest month (average temperature ~14 °C). As shown in **Figure 8**, we estimate that the Western Australian health care system will contend with close to ***7,000 Heart Failure-related admissions*** in 2019, with an additional ***490 (low to higher estimates of 350 – 560) admissions*** occurring as a *Winter Peak* compared to the *Summer Trough*.



	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	17	4	4	4	4	4	5	5	5	5	4	4	4
25–34 years	30	7	7	7	7	7	8	9	8	9	7	7	8
35–44 years	92	20	20	21	23	22	25	27	26	28	22	21	24
45–54 years	204	45	45	47	51	49	55	59	57	61	49	47	53
55–64 years	425	93	93	98	106	102	115	123	119	127	102	98	110
65–74 years	838	184	184	193	209	201	226	243	235	251	201	193	218
75–84 years	1,248	274	274	287	312	299	337	362	349	374	299	287	324
85+ years	998	220	220	230	249	240	269	289	279	299	240	230	259
ALL MALES	3,851	847	847	886	963	924	1,040	1,117	1,078	1,155	924	886	1,001
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	12	3	3	3	3	3	3	4	3	4	3	3	3
25–34 years	20	4	4	5	5	5	5	6	6	6	5	5	5
35–44 years	44	10	10	10	11	11	12	13	12	13	11	10	12
45–54 years	106	23	23	24	27	26	29	31	30	32	26	24	28
55–64 years	226	50	50	52	56	54	61	65	63	68	54	52	59
65–74 years	481	106	106	111	120	115	130	139	135	144	115	111	125
75–84 years	984	216	216	226	246	236	266	285	275	295	236	226	256
85+ years	1,238	272	272	285	310	297	334	359	347	371	297	285	322
ALL FEMALES	3,111	684	684	716	778	747	840	902	871	933	747	716	809

FIGURE 8. Annual Burden and Seasonal Pattern of Heart Failure (HF) Admissions in Western Australia

Seasonal Vulnerability Rating: Overall, Western Australia has a relatively younger population compared to the national average, is relatively wealthy, has a lower CVD-related hospitalisation compared to the national average and has a relatively dispersed population less likely to be exposed to urban pollution. Alternatively, despite its warmer climate, the South-West portion of the State contends with a marked variation in wintry versus summer climatic conditions (monthly 168mm and 11.2 °C rain and temperature differentials, respectively) that is likely to provoke *Seasonality*; particularly among vulnerable groups. Our seasonal vulnerability rating (the lowest in Australia), therefore, is –

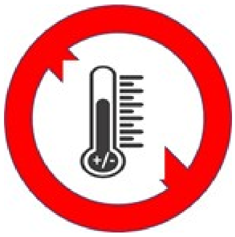
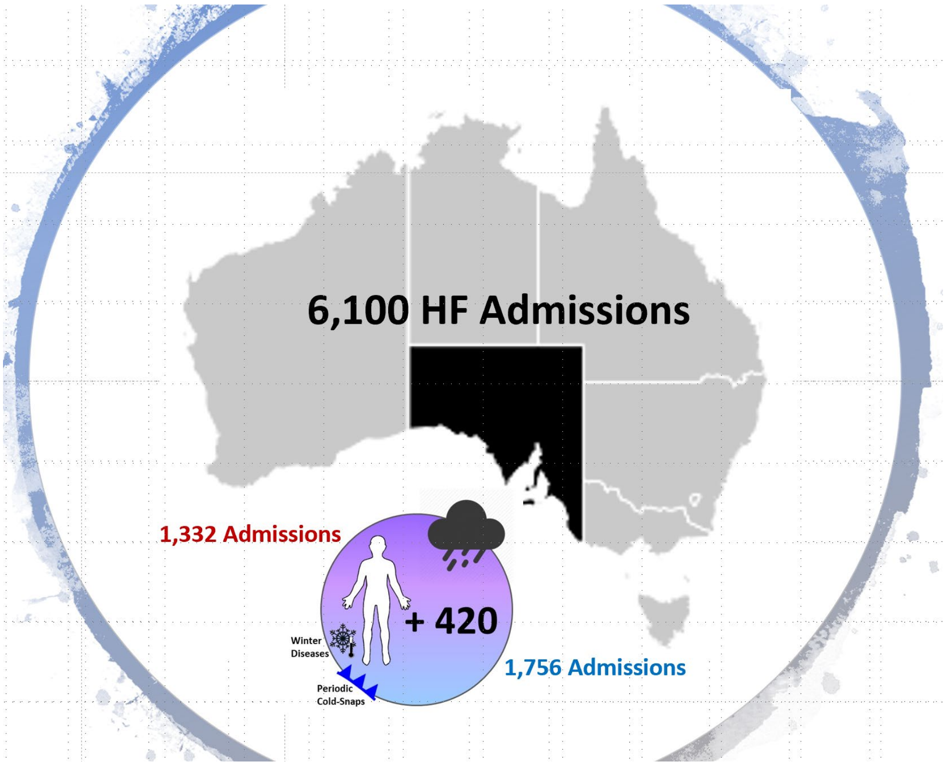


FIGURE 9. Total Heart Failure (HF) admissions across WA (blue triangle denotes the Winter Peak)

8.4 HEART FAILURE ADMISSIONS AND SEASONALITY IN SOUTH AUSTRALIA

South Australia (Mediterranean/Hot Desert Climate)

The climate in Adelaide (where the majority of South Australian's live) is mild, and generally warm and temperate; classified as **Csa** by Köppen-Geiger. The average annual temperature is ~16 °C and the annual average rainfall is ~550 mm. The driest month is February (with 15 mm of rain) compared to July (average rainfall of 76 mm). January is the warmest month (average temperature ~22 °C) and July is the coldest month (average temperature ~11 °C). As shown in **Figure 10**, we estimate that the South Australian health care system will contend with a minimum of ***6,000 Heart Failure-related admissions*** in 2019, with an additional ***420 (low to higher estimates of 360 – 490) admissions*** occurring as a *Winter Peak* compared to the *Summer Trough*.



	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	11	2	2	2	3	3	3	3	3	3	3	2	3
25–34 years	17	4	4	4	4	4	5	5	5	5	4	4	5
35–44 years	54	12	12	13	14	13	15	16	15	16	13	13	14
45–54 years	133	29	29	31	33	32	36	39	37	40	32	31	35
55–64 years	310	68	68	71	77	74	84	90	87	93	74	71	81
65–74 years	668	147	147	154	167	160	180	194	187	200	160	154	174
75–84 years	1,065	234	234	245	266	256	288	309	298	320	256	245	277
85+ years	996	219	219	229	249	239	269	289	279	299	239	229	259
ALL MALES	3,254	716	716	748	814	781	879	944	911	976	781	748	846
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	8	2	2	2	2	2	2	2	2	2	2	2	2
25–34 years	12	3	3	3	3	3	3	3	3	3	3	3	3
35–44 years	27	6	6	6	7	6	7	8	7	8	6	6	7
45–54 years	71	16	16	16	18	17	19	21	20	21	17	16	19
55–64 years	168	37	37	39	42	40	45	49	47	50	40	39	44
65–74 years	401	88	88	92	100	96	108	116	112	120	96	92	104
75–84 years	868	191	191	200	217	208	234	252	243	260	208	200	226
85+ years	1,249	275	275	287	312	300	337	362	350	375	300	287	325
ALL FEMALES	2,802	617	617	645	701	673	757	813	785	841	673	645	729

FIGURE 10. Annual Burden and Seasonal Pattern of Heart Failure (HF) Admissions in South Australia

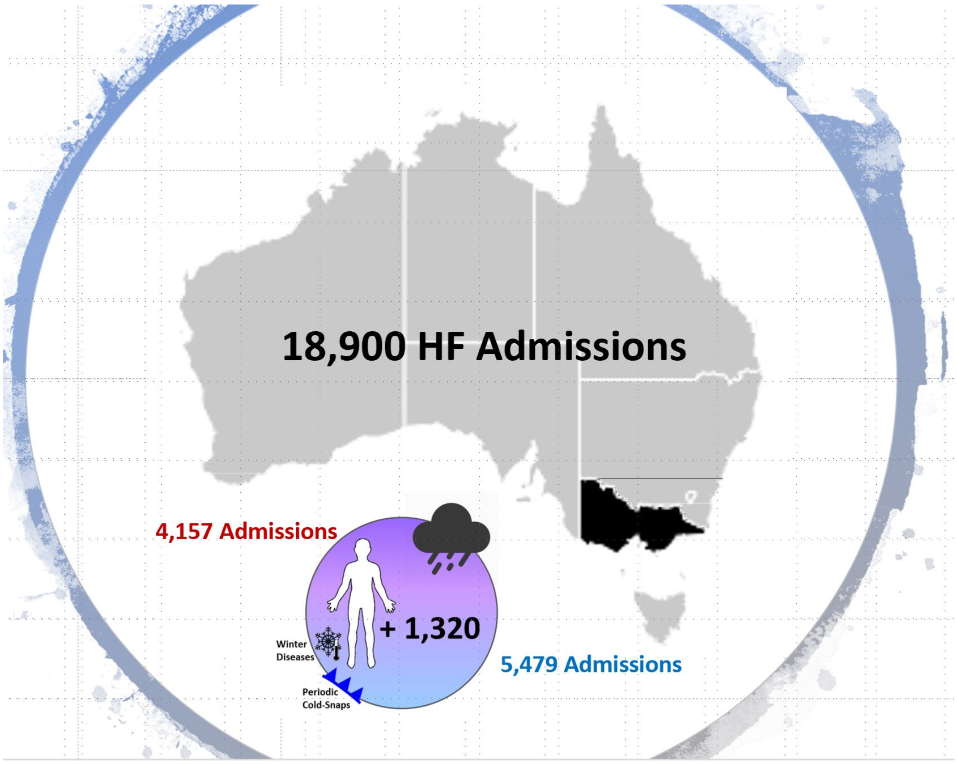
Seasonal Vulnerability Rating: Overall, South Australia has a relatively older population compared to the national average, has higher levels of poverty, has been identified as a key hot-spot for higher CVD-related hospitalisation (>55 admissions per 10,000) compared to the national average and has a relatively concentrated population more likely to be exposed to urban pollution. Moreover, despite its warmer climate, the people of South Australian contend with a marked variation in wintry versus summer climatic conditions (monthly 61mm and 11.3 °C rain and temperature differentials, respectively) that is likely to provoke *Seasonality*; particularly among vulnerable groups. Our seasonal vulnerability rating (the highest overall for Australia), therefore, is –

FIGURE 11. **Total Heart Failure (HF) admissions in Mount Gambier (blue triangle denotes the Winter Peak)**

8.5 HEART FAILURE ADMISSIONS AND SEASONALITY IN VICTORIA

Victoria (Marine West Coast Climate)

The climate in the more geographically concentrated and populated State of Victoria is generally warm and temperate; classified as **Cfb** by Köppen-Geiger. The average annual temperature is ~15 °C and the annual average rainfall is ~650 mm. In the main city Melbourne, the driest month is February, (with 44 mm of rain) compared to October (average rainfall of 71 mm). February is the warmest month (average temperature ~20 °C) and July is the coldest month (average temperature ~9 °C). As shown in **Figure 12**, we estimate that the Victorian health care system will contend with around ***19,000 Heart Failure-related admissions*** in 2019, with an additional ***1300 (low to higher estimates of 1,100 – 1,500) admissions*** occurring as a *Winter Peak* compared to the *Summer Trough*.



	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	42	9	9	10	10	10	11	12	12	13	10	10	11
25–34 years	76	17	17	18	19	18	21	22	21	23	18	18	20
35–44 years	221	49	49	51	55	53	60	64	62	66	53	51	58
45–54 years	473	104	104	109	118	114	128	137	133	142	114	109	123
55–64 years	1,015	223	223	233	254	243	274	294	284	304	243	233	264
65–74 years	2,080	458	458	478	520	499	562	603	582	624	499	478	541
75–84 years	3,345	736	736	769	836	803	903	970	937	1,003	803	769	870
85+ years	3,011	662	662	692	753	723	813	873	843	903	723	692	783
ALL MALES	10,262	2,258	2,258	2,360	2,566	2,463	2,771	2,976	2,873	3,079	2,463	2,360	2,668
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	30	7	7	7	7	7	8	9	8	9	7	7	8
25–34 years	51	11	11	12	13	12	14	15	14	15	12	12	13
35–44 years	109	24	24	25	27	26	30	32	31	33	26	25	28
45–54 years	260	57	57	60	65	62	70	75	73	78	62	60	68
55–64 years	555	122	122	128	139	133	150	161	155	166	133	128	144
65–74 years	1,243	273	273	286	311	298	336	360	348	373	298	286	323
75–84 years	2,686	591	591	618	672	645	725	779	752	806	645	618	698
85+ years	3,698	814	814	851	924	888	998	1,072	1,035	1,109	888	851	961
ALL FEMALES	8,632	1,899	1,899	1,985	2,158	2,072	2,331	2,503	2,417	2,590	2,072	1,985	2,244

FIGURE 12. Annual Burden and Seasonal Pattern of Heart Failure (HF) Admissions in Victoria

Seasonal Vulnerability Rating: Overall, Victoria has a demographic profile that is comparable to the national average. It also has relatively lower levels of poverty and, in 2015/2016, had a Gross State Product per Capita >$10,000 greater than adjacent Tasmania. The rate of CVD-related admissions in Victoria is <50 per 10,000. Alternatively, given its concentrated population distribution, Victorians are more likely to be exposed to urban pollution. Moreover, despite its warmer climate, the people of Victoria contend with a marked variation in wintry versus warmer climatic conditions (monthly 27mm and 10.9 °C rain and temperature differentials, respectively). They also contend with the notoriously fickle ("four seasons in one day") nature of the Melbourne weather that is difficult to quantify! Regardless, these meteorological conditions are likely to provoke *Seasonality*; particularly among vulnerable groups. Our seasonal vulnerability rating, therefore, is –

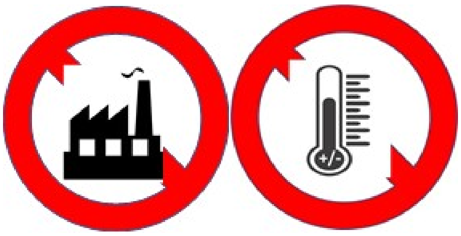
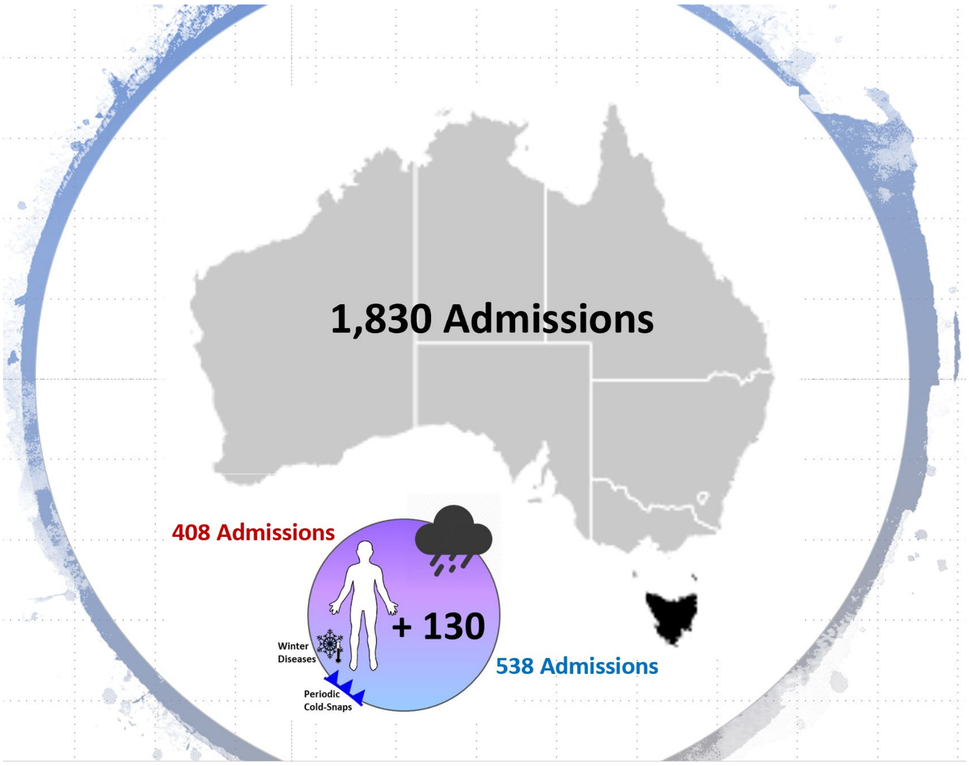


FIGURE 13. **Total Heart Failure (HF) admissions across Victoria (blue triangle denotes the Winter Peak)**

8.6 HEART FAILURE ADMISSIONS AND SEASONALITY IN TASMANIA

Tasmania (Marine West Coast Climate)

The climate in the smaller but geographically dispersed State of Tasmania is still considered warm and temperate; classified as **Cfb** by Köppen-Geiger. The average annual temperature in the main urban centre of Hobart is ~12 °C and the annual average rainfall is ~600 mm. The driest month is January (with 40 mm of rain) compared to August (average rainfall of 57 mm). January is the warmest month (average temperature ~17 °C) and July is the coldest month (average temperature ~8 °C). As shown in **Figure 14**, we estimate that the Tasmanian health care system will contend with around ***1,800 Heart Failure-related admissions*** in 2019, with an additional ***130 (low to higher estimates of 110 – 150) admissions*** occurring as a *Winter Peak* compared to the *Summer Trough*.



	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	3	1	1	1	1	1	1	1	1	1	1	1	1
25–34 years	5	1	1	1	1	1	1	1	1	1	1	1	1
35–44 years	15	3	3	3	4	4	4	4	4	4	4	3	4
45–54 years	40	9	9	9	10	10	11	12	11	12	10	9	10
55–64 years	104	23	23	24	26	25	28	30	29	31	25	24	27
65–74 years	233	51	51	54	58	56	63	68	65	70	56	54	61
75–84 years	351	77	77	81	88	84	95	102	98	105	84	81	91
85+ years	272	60	60	63	68	65	73	79	76	82	65	63	71
ALL MALES	1,023	225	225	235	256	246	276	297	287	307	246	235	266
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	2	0	0	1	1	1	1	1	1	1	1	1	1
25–34 years	3	1	1	1	1	1	1	1	1	1	1	1	1
35–44 years	8	2	2	2	2	2	2	2	2	2	2	2	2
45–54 years	22	5	5	5	6	5	6	6	6	7	5	5	6
55–64 years	56	12	12	13	14	14	15	16	16	17	14	13	15
65–74 years	135	30	30	31	34	32	36	39	38	40	32	31	35
75–84 years	271	60	60	62	68	65	73	79	76	81	65	62	70
85+ years	333	73	73	76	83	80	90	96	93	100	80	76	86
ALL FEMALES	830	183	183	191	208	199	224	241	233	249	199	191	216

FIGURE 14. Annual Burden and Seasonal Pattern of Heart Failure (HF) Admissions in Tasmania

Seasonal Vulnerability Rating: Like South Australia, Tasmania has a markedly older demographic profile when compared to the national average. It also has the highest reported levels of poverty and, in 2015/2016, had a Gross State Product per Capita that was ~$16,000 below that of New South Wales. The rate of CVD-related admissions in Tasmania is >50 per 10,000. Alternatively, given its less urbanised population distribution and wilderness areas, the people of Tasmania are less likely to be exposed to urban pollution compared to those living on the mainland. Moreover, despite impressions of a colder and harsher climate compared to continental Australia, the weather patterns in Tasmania have less variance in respect to precipitation and mean temperatures. The local population is probably more at risk of heat waves than cold snaps given the greater predictability in overall weather conditions. Our seasonal vulnerability rating, therefore, is –

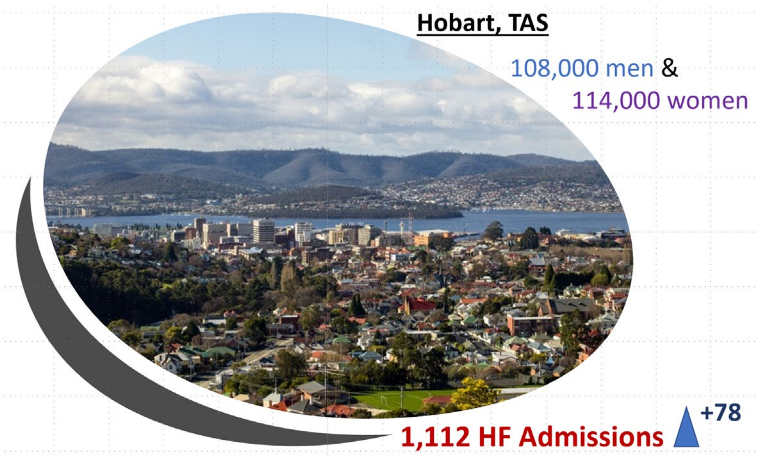
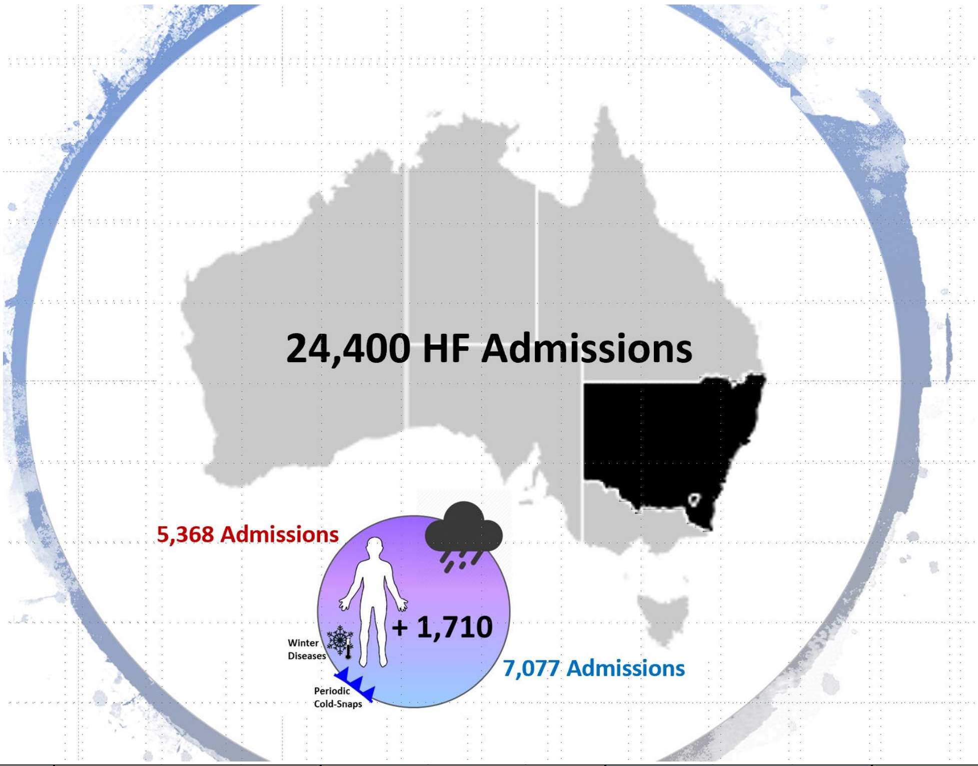


FIGURE 15. Total Heart Failure admissions across Tasmania (blue triangle denotes the Winter Peak)

8.7 HEART FAILURE ADMISSIONS AND SEASONALITY IN NEW SOUTH WALES

New South Wales (Humid Sub-Tropical Climate)

Given its large geographic footprint, the climate State of New South Wales is heterogeneous but overall warm and temperate. Most of the population (including Sydney) are exposed to a Humid Sub-Tropical climate; classified as **Cfa** by Köppen-Geiger. The average annual temperature in Sydney is ~18 °C and the annual average rainfall is ~1,300 mm. The driest month is September (with 60 mm of rain) compared to March (average rainfall of 155 mm). February is the warmest month (average temperature ~22 °C) and July is the coldest month (average temperature ~12 °C). As shown in **Figure 16**, we estimate that the New South Wales health care system will contend with ~***24,000 HF-related admissions*** in 2019, with an additional ***1,700 (low to higher estimates of 1,500 – 2,000) admissions*** occurring as a *Winter Peak* compared to the *Summer Trough*.



	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	52	11	11	12	13	12	14	15	14	16	12	12	13
25–34 years	90	20	20	21	22	22	24	26	25	27	22	21	23
35–44 years	269	59	59	62	67	65	73	78	75	81	65	62	70
45–54 years	584	129	129	134	146	140	158	169	164	175	140	134	152
55–64 years	1,318	290	290	303	329	316	356	382	369	395	316	303	343
65–74 years	2,750	605	605	632	687	660	742	797	770	825	660	632	715
75–84 years	4,356	958	958	1,002	1,089	1,045	1,176	1,263	1,220	1,307	1,045	1,002	1,132
85+ years	3,870	851	851	890	968	929	1,045	1,122	1,084	1,161	929	890	1,006
ALL MALES	13,289	2,923	2,923	3,056	3,322	3,189	3,588	3,854	3,721	3,987	3,189	3,056	3,455
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	37	8	8	8	9	9	10	11	10	11	9	8	10
25–34 years	60	13	13	14	15	14	16	17	17	18	14	14	16
35–44 years	133	29	29	30	33	32	36	38	37	40	32	30	34
45–54 years	317	70	70	73	79	76	86	92	89	95	76	73	82
55–64 years	714	157	157	164	179	171	193	207	200	214	171	164	186
65–74 years	1,602	352	352	368	400	384	432	464	448	480	384	368	416
75–84 years	3,465	762	762	797	866	832	936	1,005	970	1,040	832	797	901
85+ years	4,787	1,053	1,053	1,101	1,197	1,149	1,292	1,388	1,340	1,436	1,149	1,101	1,244
ALL FEMALES	11,114	2,445	2,445	2,556	2,778	2,667	3,001	3,223	3,112	3,334	2,667	2,556	2,890

FIGURE 16. Annual Burden and Seasonal Pattern of Heart Failure Admissions in New South Wales

Seasonal Vulnerability Rating: Like its populous neighbour Victoria, not surprisingly, New South Wales has a demographic profile that resembles that of the national average. It is also one of the wealthiest States with lower levels of poverty and a higher Gross State Product per Capita than most other parts of the country. The rate of CVD-related admissions in New South Wales, whilst lower than that of South Australia and Tasmania is still around 50 per 10,000. Moreover, given its large, industrialised cities, a large proportion of the New South Wales population are likely to be exposed to urban pollution. Despite its sub-tropical climate, the relatively large variance in rainfall and temperatures is likely to provoke *Seasonality*. Our seasonal vulnerability rating, therefore, is –

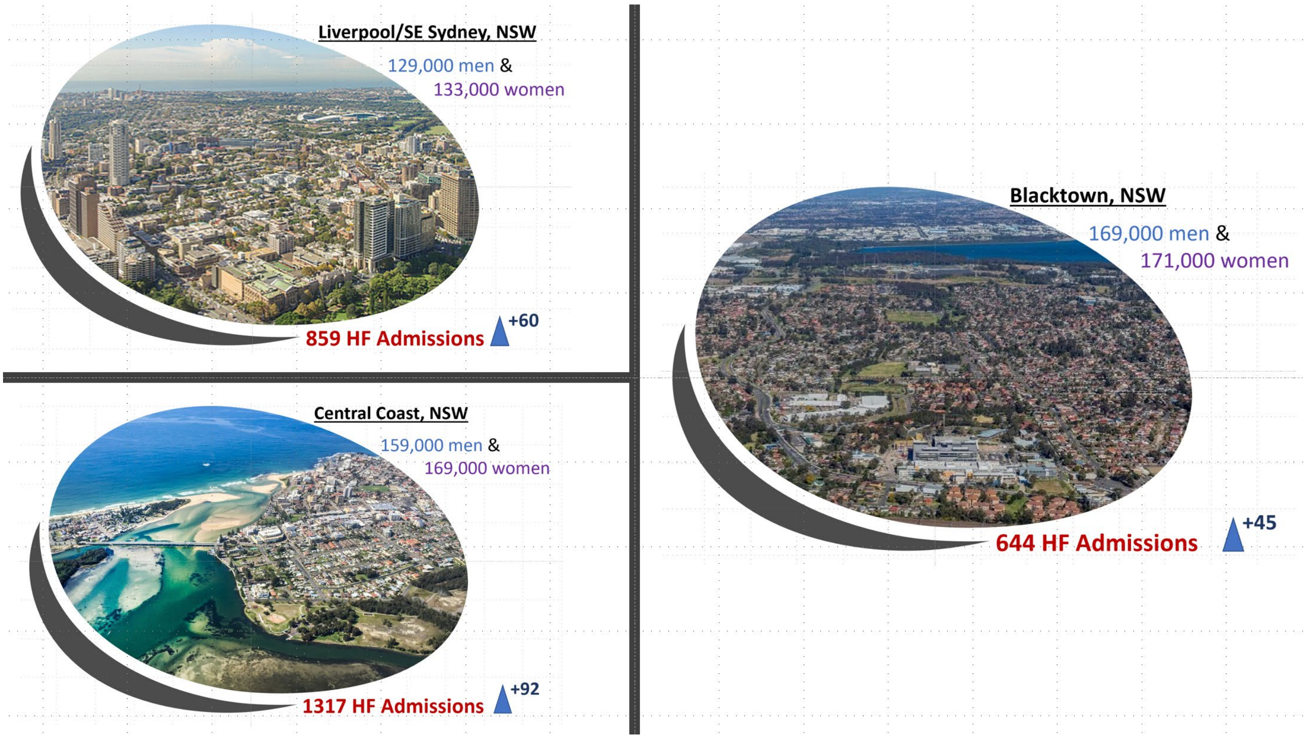
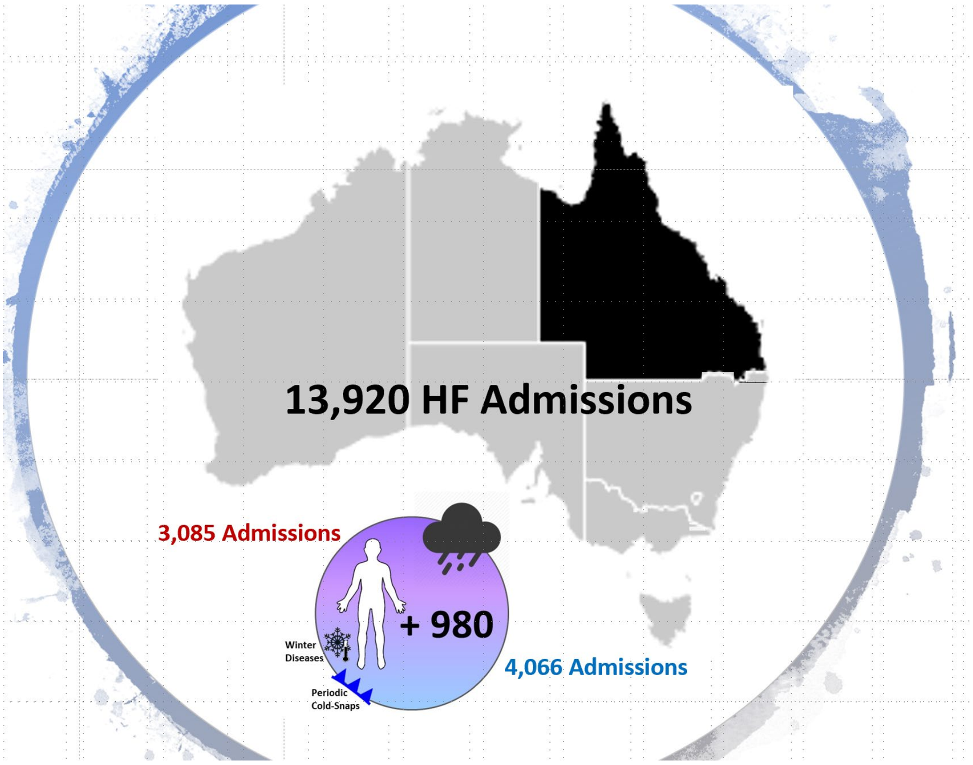


FIGURE 17. Total Heart Failure (HF) admissions across NSW (blue triangle denotes the Winter Peak)

8.8 HEART FAILURE ADMISSIONS AND SEASONALITY IN QUEENSLAND

Queensland (Humid Sub-Tropical /Tropical Monsoon Climate)

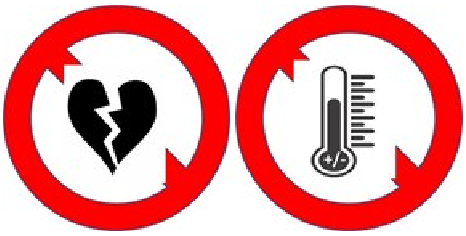
The climate of Queensland is heterogeneous but overall warm and tropical. A good proportion of the population (from the Gold Coast to Sunshine Coast) are exposed to a Humid Sub-Tropical climate; classified as **Cfa** by Köppen-Geiger. In Brisbane, the average annual temperature is ~20 °C and the annual average rainfall is ~1,200 mm. The driest month is September (with 34 mm of rain) compared to February (average rainfall of 167 mm). January is the warmest month (average temperature of ~25 °C) and July is the coldest month (average temperature ~15 °C). As shown in **Figure 18**, we estimate that the Queensland health care system will contend with ~***14,000 Heart Failure-related admissions*** in 2019, with an additional ***1,000 (low to higher estimates of 850 – 1,100) admissions*** occurring as a *Winter Peak* compared to the *Summer Trough*.



	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	33	7	7	8	8	8	9	10	9	10	8	8	9
25–34 years	53	12	12	12	13	13	14	15	15	16	13	12	14
35–44 years	164	36	36	38	41	39	44	48	46	49	39	38	43
45–54 years	381	84	84	88	95	91	103	110	107	114	91	88	99
55–64 years	822	181	181	189	206	197	222	239	230	247	197	189	214
65–74 years	1,747	384	384	402	437	419	472	507	489	524	419	402	454
75–84 years	2,589	570	570	595	647	621	699	751	725	777	621	595	673
85+ years	2,000	440	440	460	500	480	540	580	560	600	480	460	520
ALL MALES	7,789	1,714	1,714	1,791	1,947	1,869	2,103	2,259	2,181	2,337	1,869	1,791	2,025
	HF Admissions	Summer (22%)	Low (22%)	High (23%)	Autumn (25%)	Low (24%)	High (27%)	Winter (29%)	Low (28%)	High (30%)	Spring (24%)	Low (23%)	High (26%)
<25 years	24	5	5	6	6	6	6	7	7	7	6	6	6
25–34 years	36	8	8	8	9	9	10	10	10	11	9	8	9
35–44 years	83	18	18	19	21	20	23	24	23	25	20	19	22
45–54 years	208	46	46	48	52	50	56	60	58	62	50	48	54
55–64 years	445	98	98	102	111	107	120	129	125	134	107	102	116
65–74 years	999	220	220	230	250	240	270	290	280	300	240	230	260
75–84 years	1,970	433	433	453	493	473	532	571	552	591	473	453	512
85+ years	2,467	543	543	568	617	592	666	716	691	740	592	568	642
ALL FEMALES	6,233	1,371	1,371	1,434	1,558	1,496	1,683	1,808	1,745	1,870	1,496	1,434	1,621

FIGURE 18. Annual Burden and Seasonal Pattern of Heart Failure Admissions in Queensland

Seasonal Vulnerability Rating: Like its more populous neighbour New South Wales, Queensland has a demographic profile that resembles that of the national average. It is also one of the wealthiest States with lower levels of poverty and a higher Gross State Product per Capita than most other parts of the country. Alternatively, the rate of CVD-related admissions in Queensland is markedly elevated compared to the rest of the country (~56 admissions/10,000). Although Queensland has large urban centres, a large portion of its population are dispersed in rural areas with minimal exposure to urban pollution. Despite its sub-tropical/tropical climate, the relatively large variance in rainfall and temperatures is likely to provoke *Seasonality* in Queensland; particularly it's South-East region. Our seasonal vulnerability rating, therefore, is –



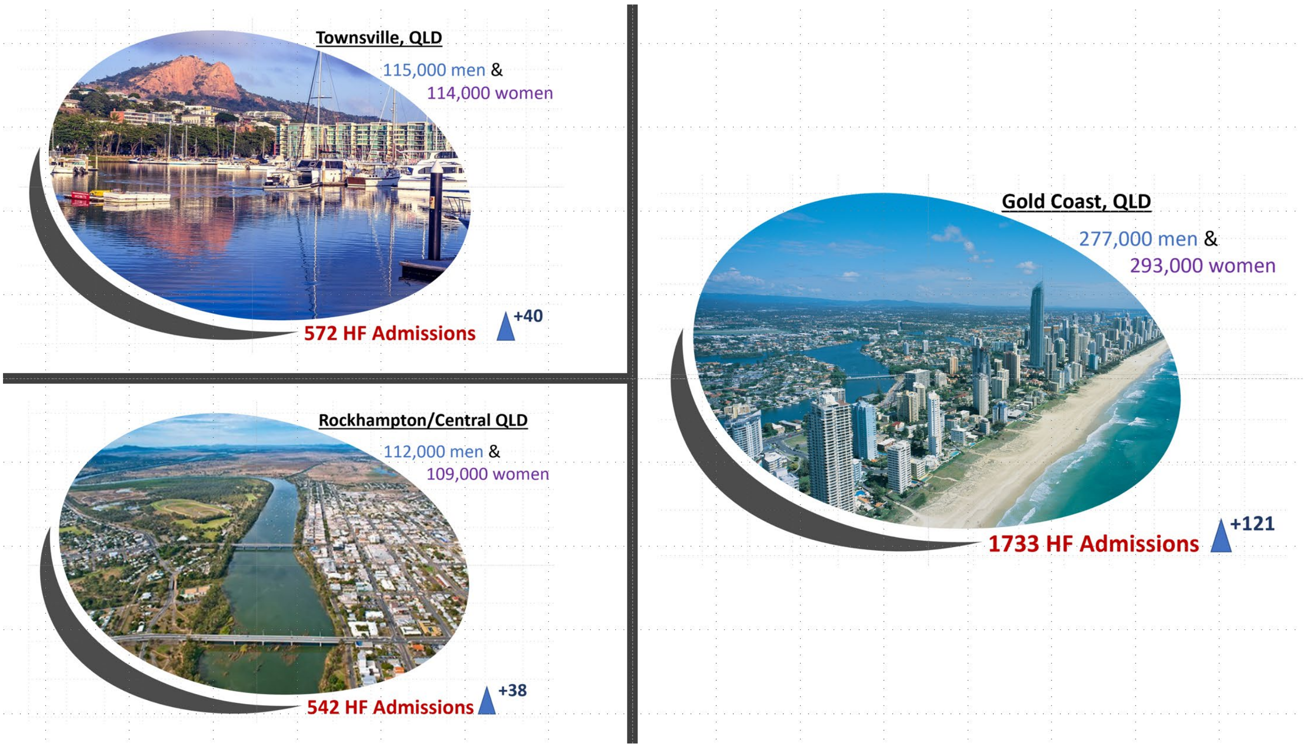


FIGURE 19. Total Heart Failure admissions across Queensland (blue triangle denotes the Winter Peak)

8.9 AUSTRALIAN CAPITAL TERRITORY

The climate in the ACT is warm and temperate; classified as **Cfb** by Köppen-Geiger. In Canberra, the average annual temperature is ~13 °C and the annual average rainfall is ~650 mm. The driest month is June (with 38 mm of rain) compared to October (average rainfall of 64 mm). January is the warmest month (~21 °C) and July is the coldest month (~ 6 °C). **Figure 20** shows the estimated number of Heart Failure-related admissions in 2019 (primary diagnosis) and difference between those occurring in Summer (312 admissions) compared to Winter (411 admissions).

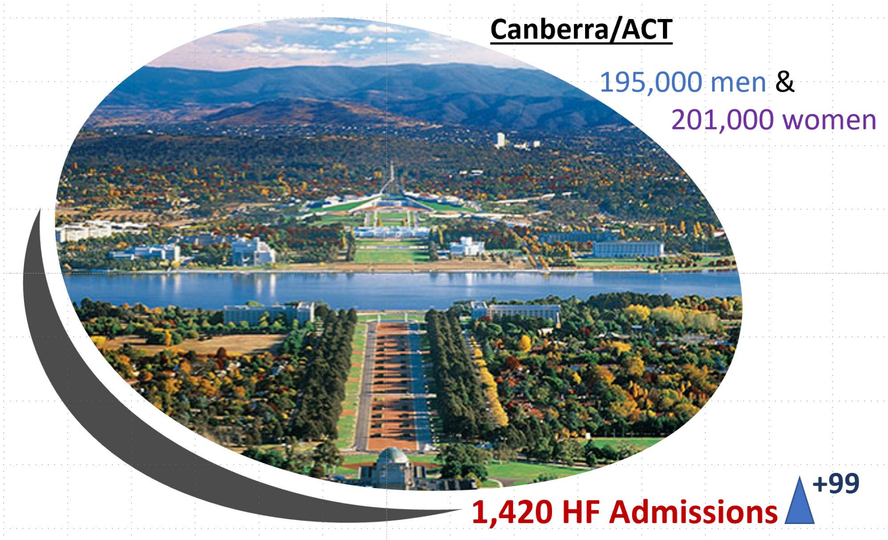


FIGURE 20. Pattern of Heart Failure admissions in the ACT (blue triangle denotes the Winter Peak)

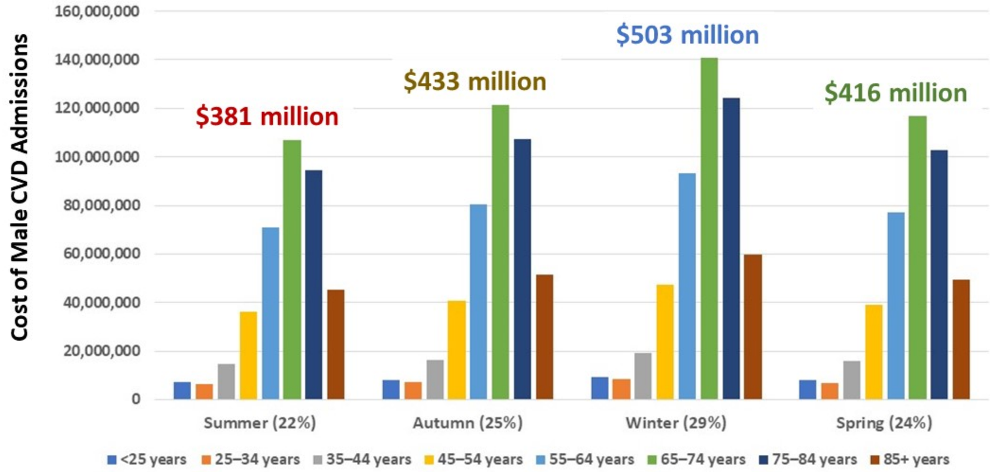
8.10 NORTHERN TERRITORY

The Northern Territory is large geographic region with a relatively small population (128,000 men and 119,000 women) exposed to very different climates. In the north (the location of the most populous centre Darwin), the climate is tropical (classified as **Aw** by Köppen-Geiger) with warm temperatures year-round (mean temperatures ~27 °C) but with a distinctive dichotomous distribution of rainfall (~1700 per annum) in the “Winter” (dry) versus “Summer” (wet and humid). In the south, including Alice Springs in Central Australia (classified as **BSh** by Köppen-Geiger) the population is exposed to hot desert conditions with very hot summers, arid conditions and mild winters with large diurnal variations in temperature. As recently noted, the rate of Heart Failure admissions among the Indigenous peoples of Central Australia are markedly higher and affect more younger men and women (in particular) than the rest of Australia and indeed their non-Indigenous neighbours. [23] Despite the strong likelihood that *Seasonality* will still influence the pattern of Heart Failure admissions in the region (particularly among vulnerable individuals and communities), more focussed research is required to reveal the nature and extent of its influence/burden in this regard.

9. COUNTING THE COST OF CVD & HEART FAILURE ADMISSIONS & SEASONALITY

By any measure the cost-burden of CVD in Australia is substantial; with hospital admissions the greatest cost. While there are many preventative strategies to reduce the burden of disease associated with CVD (many of which are under-utilised), consistent with the lack of recognition around *Seasonality*, few if any public health policy and/or clinical guideline documents consider the cost-benefits of proactively addressing it. If one were to reasonably assume that the low rate of hospitalisations in Summer (*Summer Troughs)* represent a baseline against which the cost of *Seasonality* (including Winter Peaks) might be measured, the potential cost-benefits of this phenomenon are substantial. As shown in **Figure 21a** (men) and **Figure 22b** (women), when assuming a conservative cost of $5,000 per admission (equivalent to 2-3 days stay) CVD-related admissions among men and women in 2019 will amount to ***$1.73 and $1.23 billion***, respectively. In considering the total expenditure of ***$3 billion*** in hospital costs attributable to CVD each year, we estimate that if it were indeed possible to minimise *Seasonality* by eliminating greater rates of hospitalisation in Winter, Autumn and Spring, a total of ***$360 million in cost-savings per annum*** could be achieved.

A. Cost of CVD Admissions (MEN)



B. Cost of CVD Admissions (WOMEN)

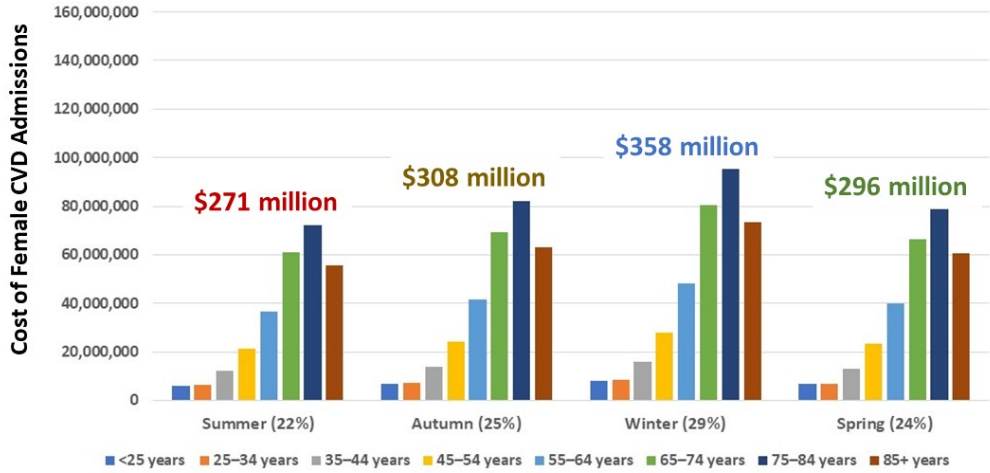
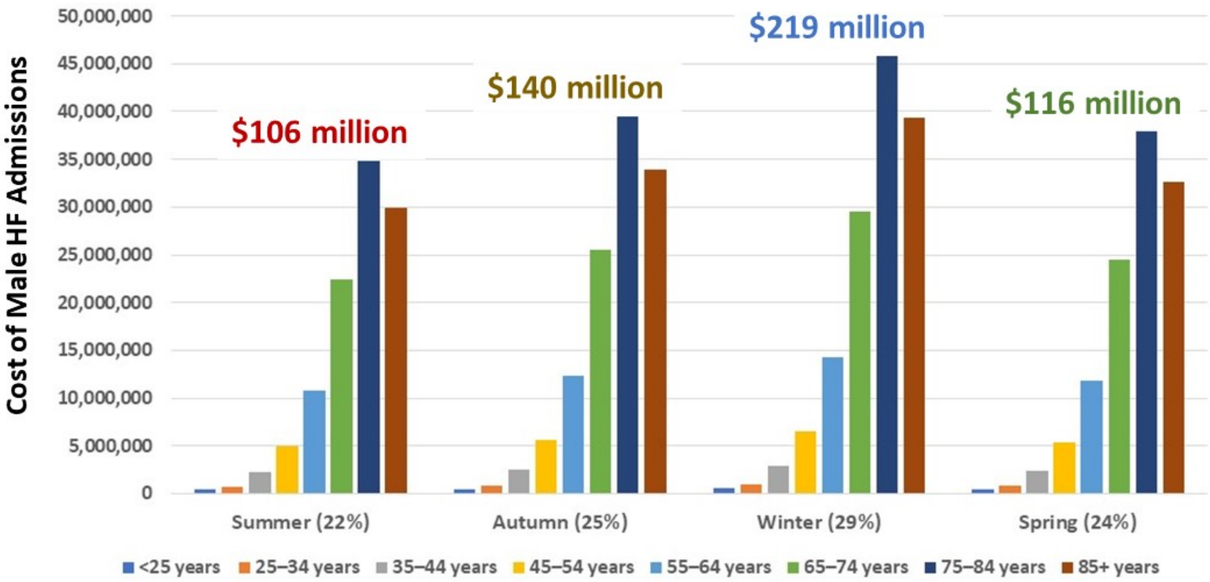


FIGURE 21. Seasonal Cost of CVD-Related Admissions among Australian Men (A) and Women (B)

Even when accounting for the most obvious and readily diagnosable forms of Heart Failure only, the overall burden imposed by this deadly and disabling syndrome is substantial; particularly given that the average length of stay is 5-7 days and the cost is much more than the average CVD admission. [13] For this analysis we've assumed the average cost of a Heart Failure admission is $12,000. On this basis, in 2019 we estimated that Heart Failure-related admissions among men and women will conservatively amount to ***$581 and $399 million***, respectively. In considering the total expenditure of ***$980 million*** in hospital costs attributable to a primary diagnosis of Heart Failure each year, we estimate that if it were indeed possible to minimise *Seasonality* by eliminating greater rates of hospitalisation in Winter, Autumn and Spring, a total of ***$204 million in cost-savings per annum*** could be achieved – see **Figure 22**.

A. Cost of HF Admissions (Men)



B. Cost of HF Admissions (Women)

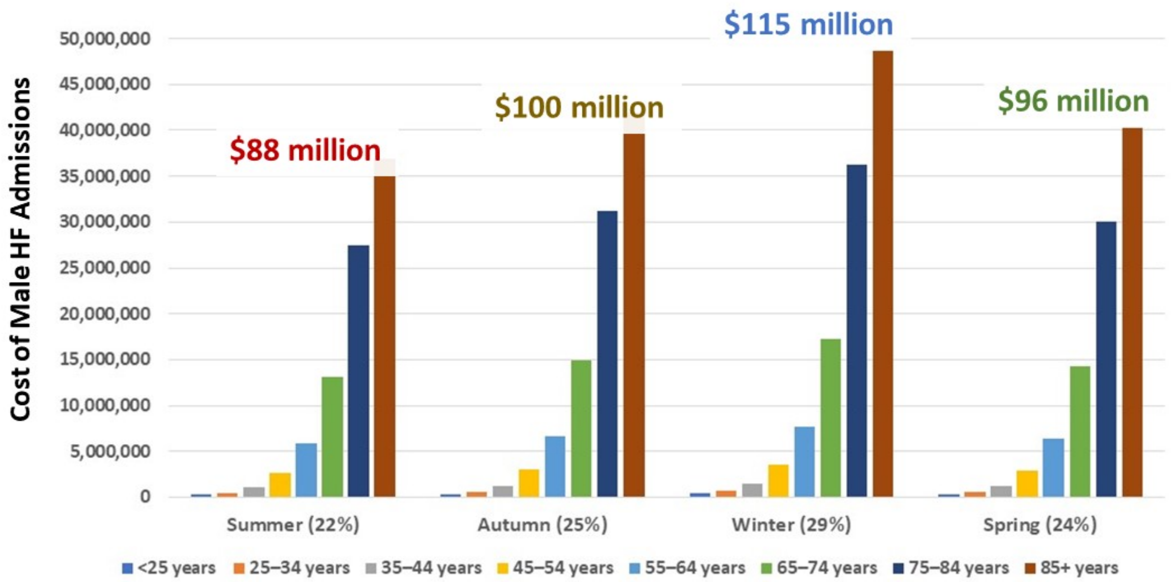


FIGURE 22. Seasonal Cost of Heart Failure (HF) Admissions among Australian Men (A) and Women (B)

10. FUTURE TRENDS WITHIN AN INCREASINGLY UNSTABLE CLIMATE

Until recently, high-income countries routinely reported steady declines in CVD-related events. However, as predicted by a previous Australian report, [21] a rising prevalence of sedentary behaviour, poor diets and related obesity, has now reversed these health gains in the United Kingdom.[22] Even if this disturbing trend has yet to occur in Australia, the pool of older Australians at risk of developing Heart Failure is steadily increasing. It is on this basis, that we applied an increase in hospitalisation rates by 3.5% per 5-years to projected increases in the Australian population for the years 2025 and 2030. **Figure 23** and **Figure 24** show that without a concerted effort, the burden of CVD, Heart Failure and *Seasonality* (notably *Winter Peaks*) in hospital services will steadily rise.

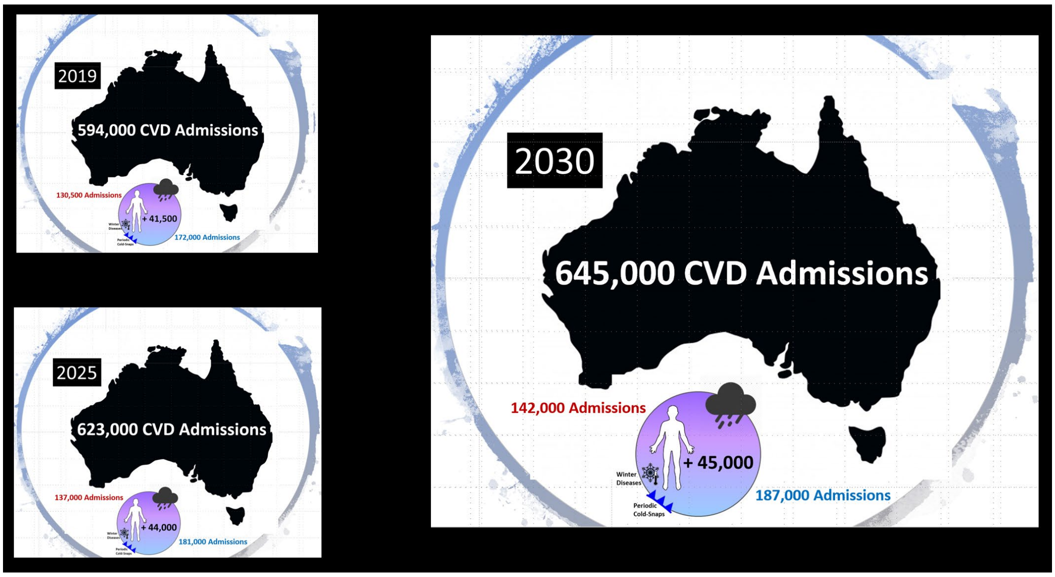


FIGURE 23. **Future Trends in CVD-related Admissions & Seasonality by 2030**

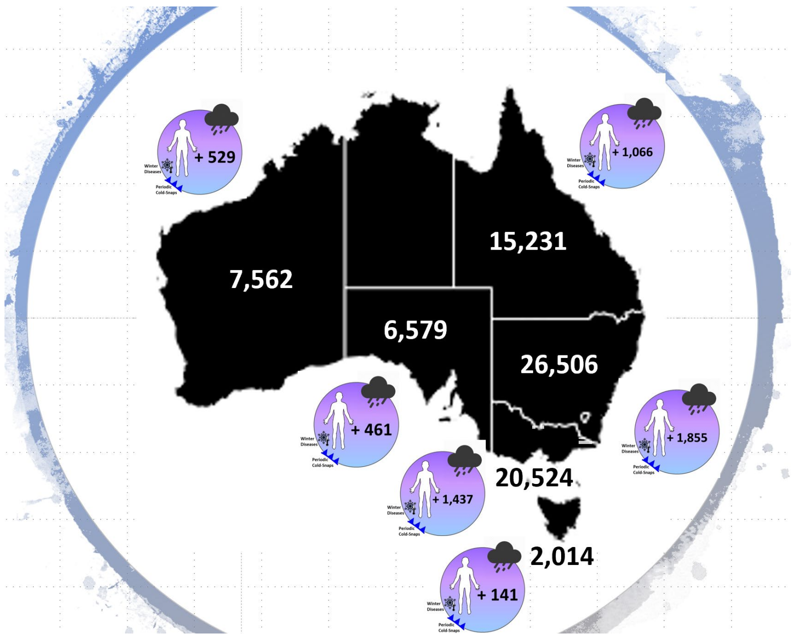


FIGURE 24. **Projected Heart Failure Admissions & Seasonality Across Australia in 2030**

11. THE CLINICIAN'S PERSPECTIVE

This Report challenges the traditional way in which we assess cardiovascular risk and asks us to consider the novel concept that *Seasonality* (i.e. *changing seasons and climactic/weather conditions)* is a risk factor for CVD. As Professor Burrell (from the perspective of a Consultant Physician routinely coping with a higher caseload of very sick patients admitted to hospital in Winter) comments:

"We ask our patients about their age, family history, and traditional CVD risk factors such as high blood pressure, smoking and lipid levels, but we don't consider the environmental hazards of temperature, pollution, and air quality."

As such the concept of *Seasonality* will be new to most clinicians working in acute medicine, cardiology, aged care, general practice and primary care. The evidence summarized in this Report is strong, compelling and challenging. *Seasonality* for patients with CVD (i.e. the distinctive and repeated ebbs and flows in the rate of cardiovascular events [most notably hospital admissions and deaths among vulnerable individuals] according to the changing seasons and climactic/weather conditions) will require a shift in our clinical perspective and approach. Adding further complexity to this definition is that *Seasonality* also refers to the spike in hospital admissions and deaths during acute weather events (e.g. an unseasonal cold-snap or particularly intense heat wave). As Professor Justin Beilby (from the perspective of a General Practitioner [GP] also coping with clinically unstable patients in the colder months) also comments:

"What this means for a busy GP is that during winter months and shortly thereafter in early spring there will be a "predictable" rise in patients with all forms of CVD experiencing a hospital admission and death in some circumstances."

For a GP who will have many "at risk" patients with CVD this will require an increased awareness and a heightened clinical focus on the causes and consequences of *Seasonality*. As Professor Simon Stewart (from the perspective of the expert Cardiac Nurse working closely with the patient and within a multidisciplinary team) further comments:

"The concept of building "Seasonal Resilience" by supporting and enabling vulnerable individuals to make good decisions, work towards clinical stability and improve their overall physical and mental health, represents a worthy challenge to the whole health care team; from the hospital to primary care setting."

So, what is needed now to prevent at risk people with CVD presenting to hospital when the weather changes? Clearly, both acute hospital and primary health providers have valuable roles to play in designing appropriate intervention models. Firstly, we need to clarify the key areas to intervene within hospital and urban, semi-rural and rural general practice and to test different approaches. And next we need to align our goals to test a hospital and health service approach to keep Australians with CVD and, specifically Heart Failure, out of hospital. For general practice and primary care to embrace this model more widely what is now needed is clarity on what the most ideal interventions in day to day clinical practice are. From a more regional primary care perspective Primary Healthcare Networks and other key partners will need to discuss how to intervene in their own specific region, based on the final assessment of their regional vulnerability to *Seasonality*.

12. LIMITATIONS

Any consideration of these data and their clinical and public health implications needs to be tempered by some important limitations. While we were able to rely on accurate population data from the ABS (noting the last Census was conducted in 2016), Australia remains poorly positioned to understand the full scope of the burden imposed by Heart Failure. As highlighted in previous reports of this kind,[13] there are few population cohort studies capturing imaging data to fully categorise Heart Failure in Australia (the Canberra Heart Study [24] and Heart of the Heart Study in Central Australia [25] being notable exceptions). Moreover, the underlying methods used to code and report on Heart Failure admissions in Australia, when compared to equivalent reports elsewhere in the world, undoubtedly mis-represent/under-report the true numbers; particularly in respect to it being a contributory cause of admissions and recognising Heart Failure with preserved ejection fraction (that is hardest to diagnose). At the same time, our understanding of *Seasonality* and how it influences the pattern of Heart Failure events in different individuals and regions remains in its infancy; our model of Seasonal Vulnerability [8] predicts that there will indeed be key differences based on climate and adaptation from a community to individual perspective. It is for this reason we provide some regional perspectives and then introduce our 5-point system to emphasise how the burden of *Seasonality* will vary across Australia. As with other concepts introduced in this report, this system needs to be further investigated and validated. Finally, we deliberately avoided calculating how many premature deaths might be triggered by *Seasonality*; in preference to focussing on the pattern of hospital admissions. However, seasonal mortality is undoubtedly an additional phenomenon that requires attention. It is sobering to note that even with the best of care and hospital avoidance programs, within 30-days, 5-10% of individuals hospitalised with Heart Failure will have died. [26]

13. CONCLUDING REMARKS

Based on an increasingly sophisticated and insightful program of research (a good portion of which was funded by a Program of Research Grant from the *National Health and Medical Research Council of Australia*), these data provide a sobering message. During another "mild" winter, hospitals across Australia are dealing with a deluge of patients with CVD that will overwhelm already limited resources. A major portion of these individuals will have the potentially deadly and disabling syndrome Heart Failure. The typical one-dimensional figures used to describe the burden of CVD and Heart Failure in Australia do not adequately describe the enormous differential in the volume hospital cases between the colder and warmer months – see **Executive Summary**. As such, we hope this Report will stimulate greater interest in understanding, predicting and preventing cardiovascular *Seasonality*; the potential cost-savings being enormous.

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15. APPENDIX

15.1 AIHW Hospitalisation Data Used in this Report

Table 2.2: CVD hospitalisations (principal diagnosis), by age and sex, 2015–16

	Hospitalisations per 100,000 population		
Age group (years)	Males	Females	Persons
<25	161	144	153
25–34	310	309	310
35–44	799	660	729
45–54	2,087	1,184	1,628
55–64	4,556	2,254	3,381
65–74	8,918	4,877	6,868
75–84	15,529	10,372	12,748
85+	21,517	16,170	18,142

Notes:

1. CVD is classified according to the International Statistical Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM) (9th edition). See Data Sources tab for codes.
2. Hospitalisations for which the care type was reported as Newborn with no qualified days, and records for Hospital boarders and Posthumous organ procurement have been excluded.

Source: AIHW National Hospital Morbidity Database.

Table 2.5: Heart failure and cardiomyopathy hospitalisations (principal diagnosis), by age and sex, 2015–16

	Hospitalisations per 100,000 population		
Age group (years)	Males	Females	Persons
<25	4	3	4
25–34	15	10	12
35–44	51	25	38
45–54	119	62	90
55–64	290	150	219
65–74	779	437	606
75–84	2,387	1,644	1,986
85+	5,917	4,473	5,005

Notes:

1. Heart failure and cardiomyopathy are classified according to the International Statistical Classification of Diseases, 10th Revision, Australian Modification (ICD-10-AM) (9th edition). See Data Sources tab for codes.
2. Hospitalisations for which the care type was reported as Newborn with no qualified days, and records for Hospital boarders and Posthumous organ procurement have been excluded.

Source: AIHW National Hospital Morbidity Database.

15.2 Population Profile of Australia in 2018 (ABS Data)

Australian Population				
Age group (years)	Males	Females	% Males	% Female
<25	4,071,151	3,862,233	33%	31%
25–34	1,862,042	1,877,850	15%	15%
35–44	1,650,889	1,665,355	13%	13%
45–54	1,568,466	1,631,415	13%	13%
55–64	1,411,425	1,477,361	11%	12%
65–74	1,089,995	1,134,948	9%	9%
75–84	552,165	633,897	4%	5%
85+	191,268	312,400	2%	2%
Total	12,397,401	12,595,459		

WA Population				
Age group (years)	Males	Females	% Males	% Female
<25	424,913	403,766	33%	31%
25–34	197,839	196,842	15%	15%
35–44	180,329	177,387	14%	14%
45–54	171,506	171,489	13%	13%
55–64	146,425	150,493	11%	12%
65–74	107,568	109,978	8%	8%
75–84	52,267	59,840	4%	5%
85+	16,866	27,684	1%	2%
Total	1,297,713	1,297,479		

SA Population				
Age group (years)	Males	Females	% Males	% Female
<25	269,509	255,888	31%	29%
25–34	116,004	116,551	14%	13%
35–44	106,689	107,077	12%	12%
45–54	111,632	114,811	13%	13%
55–64	106,840	111,858	12%	13%
65–74	85,761	91,651	10%	10%
75–84	44,622	52,778	5%	6%
85+	16,827	27,924	2%	3%
Total	857,884	878,538		

VIC Population				
Age group (years)	Males	Females	% Males	% Female
<25	1,049,862	992,867	33%	30%
25–34	507,954	513,535	16%	16%
35–44	433,743	437,315	14%	13%
45–54	397,722	419,541	12%	13%
55–64	349,850	369,862	11%	11%
65–74	266,981	284,373	8%	9%
75–84	140,128	163,390	4%	5%
85+	50,879	82,673	2%	3%
Total	3,197,119	3,263,556		

NSW				
Age group (years)	Males	Females	% Males	% Female
<25	1,292,076	1,223,418	33%	30%
25–34	597,281	598,978	15%	15%
35–44	527,983	530,000	13%	13%
45–54	491,129	511,739	12%	13%
55–64	454,469	476,051	11%	12%
65–74	352,962	366,488	9%	9%
75–84	182,474	210,773	5%	5%
85+	65,411	107,009	2%	3%
Total	3,963,785	4,024,456		

TAS Population				
Age group (years)	Males	Females	% Males	% Female
<25	81,463	75,653	31%	28%
25–34	31,731	31,937	12%	12%
35–44	29,399	30,928	11%	12%
45–54	33,627	35,860	13%	13%
55–64	35,997	37,578	14%	14%
65–74	29,928	30,883	11%	12%
75–84	14,689	16,493	6%	6%
85+	4,600	7,435	2%	3%
Total	261,434	266,767		

QLD Population				
Age group (years)	Males	Females	% Males	% Female
<25	836,265	800,739	34%	32%
25–34	352,149	360,853	14%	14%
35–44	322,073	333,449	13%	13%
45–54	319,783	335,207	13%	13%
55–64	283,615	296,935	11%	12%
65–74	224,279	228,625	9%	9%
75–84	108,448	119,837	4%	5%
85+	33,796	55,163	1%	2%
Total	2,480,408	2,530,808		

15.3 Summary of Report Findings by State / Territory / Locality (2019 Figures)

Location	Hospital Admissions for Heart Failure Total 2019	Hospital Admissions for Heart Failure Winter 2019	Additional Winter Hospital Admissions for Heart Failure
ACT (Canberra)	**1,420**	**411**	**99**
New South Wales	**24,400**	**7,077**	**1,710**
Blacktown	644	187	45
Central Coast	1,317	382	92
Liverpool/SW Sydney	859	249	60
Queensland	**13,920**	**4,066**	**980**
Gold Coast	1,733	503	121
Rockhampton/Central QLD	542	147	38
Townsville	572	166	40
South Australia	**6,100**	**1,756**	**420**
Mount Gambier	781	226	55
Tasmania	**1,830**	**538**	**130**
Hobart	1,112	323	78
Launceston	505	146	35
Victoria	**18,900**	**5,479**	**1,320**
Geelong	973	282	68
North East Melbourne	1328	385	93
Shepparton	504	146	35
Western Australia	**7,000**	**2,019**	**490**
Bunbury	827	240	58
Mandurah	588	170	41