

# HOW MEN AGE: INSIGHTS FROM THE CHAMP STUDY

## 1. INTRODUCTION

Men live less long than women, so there are fewer of them at older ages. And yet they still make up 45% of the Australian population aged 70+ (ABS 2016).

This means that older men are also less likely to be the subjects of age-related research, even though some of their experiences are unique. A group of researchers, led by Prof Robert Cumming, sought to change that. In 2005, they embarked on a project to study how the health of men changes as they get older.

The result was the *Concord Health and Ageing in Men Project* (CHAMP), one of the most comprehensive studies of older men's health ever conducted anywhere. It started with a cohort of 1,705 men aged over 70 years living in the community in Sydney (around Burwood, Canada Bay, and Strathfield).

The study tracked their lives as they progressed to old age and as their health, relationships, and circumstances changed; and ultimately, for some, how they passed away (Fig. 1). Each follow-up since 2005 collected extensive answers to questionnaires, as well as physical and cognitive performance examinations and blood tests. The study was made possible via a series of NHMRC grants, with additional funding from the Ageing and Alzheimer's Research Foundation at Concord Hospital, the University of Sydney Medical Foundation, and most recently the Australian Research Council Centre of Excellence in Population Ageing Research (CEPAR).

The original team included an epidemiologist (Robert Cumming, a former CEPAR Chief Investigator), an expert in

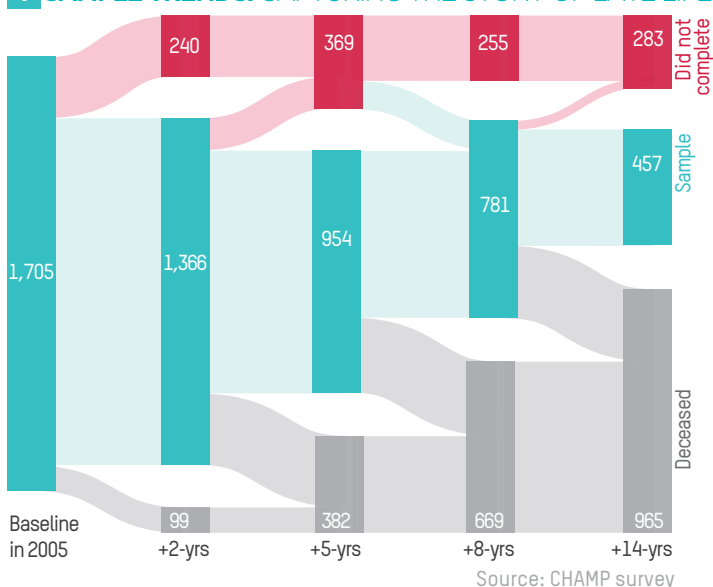
reproductive hormones (David Handelsman), specialists in bone and mineral disorders (Markus Seibel and the late Phil Sambrook), four geriatricians: two with interest in dementia (Helen Creasey and Louise Waite), one with expertise in the biology of ageing (David Le Couteur), and one with training in clinical epidemiology (Vasi Naganathan).

The team of Investigators expanded to include an epidemiologist specialising in chronic pain (CEPAR Chief Investigator Fiona Blyth), a sociologist (the late Hal Kendig), a nutritionist (Vasant Hirani), a biologist (Steve Simpson), and a dentist (Clive Wright).

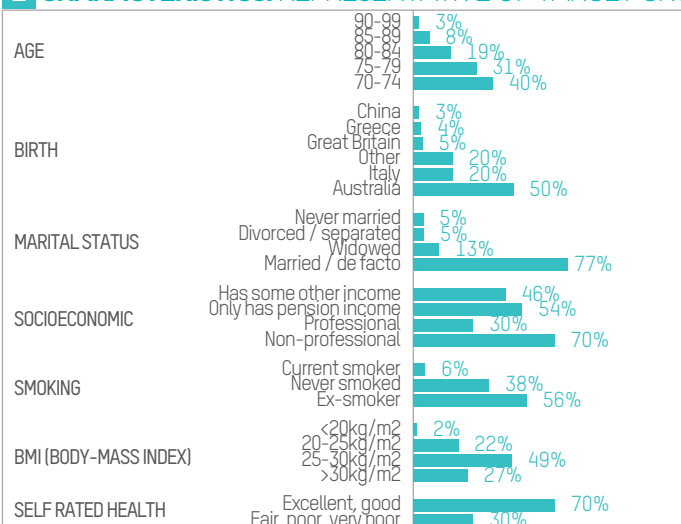
So far, the project has led to over 100 academic papers on biological, clinical, and psychosocial aspects of ageing, with thousands of citations. This Fact Sheet summarises some of these insights, describing the patterns of healthy and less-than-healthy ageing, and the factors related to each. In future, men are expected to live longer, healthier lives, and in a small part it will be thanks to lessons learned from CHAMP.

Before turning to what these 1,705 men can teach us about ageing, it is worth pausing to see who they are or were. Importantly, they are broadly representative of their generation of men in Australia. A good proportion came from Southern Europe, a key source of post-war migration (Fig. 2). But the typical (median) participant was born in Australia. He once smoked and worked in a blue-collar job. By the start of the survey, he had become a full pensioner (with no other income), quit smoking, and was still living with his partner. His health was good or excellent, with a disease prevalence in line with national studies (Holden et al. 2005).

### 1 SAMPLE TRENDS: CAPTURING THE STORY OF LATE LIFE



### 2 CHARACTERISTICS: REPRESENTATIVE OF TARGET GROUP



## 2. WHY DO SOME PEOPLE AGE FASTER AND DIE SOONER?

One school of thought is that biological ageing is the accumulation of damage to our body. As this damage compounds, we become more susceptible to illness or injury and are increasingly less likely to bounce back. In the end, the rate of damage exceeds our capacity to recover. Yet such health trajectories differ based on our traits, behaviours, and the environments in which we live.

One way to improve healthy ageing is to understand and alter health deficit trajectories before major medical issues arise. This is the story of CHAMP. Its detailed data helps us see how age related health problems correlate with different factors and how these relate over time. Such insights have predictive power even if proving causality is elusive. These allow us to devise strategies for healthy ageing – not only adding years to life, but life to years.

Four syndromes have been traditionally thought to become more common in older people: incontinence, impaired cognition (dementia), immobility, and instability (frequent falls). These *geriatric giants* were first identified by Bernard Isaacs in 1965. They describe functional (rather than just medical) challenges faced by older people. The prevalence of these ageing syndromes rises sharply for men in their mid-80s but remains below a third even among the oldest old and few rate their own health poorly (Fig. 3).

The field has evolved to include other syndromes that capture the decline in resilience and age-related problems, such as physical frailty, low muscle mass and bone health (Section 3), and ageing-related under-nutrition (Section 4). For example, frailty can be measured either via a comprehensive assessment of health deficits or by the presence of three of five physical characteristics: exhaustion, weight loss, slow walking speed, inactivity, and weak grip strength. By the time CHAMP men were in their 90s, half were considered frail.

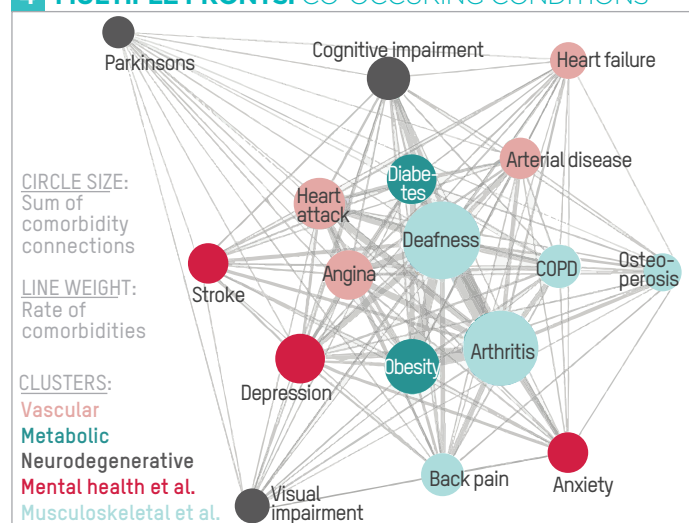
CHAMP researchers found that frail men, compared to those deemed *robust*, were twice as likely to see a doctor,

three times more likely to go to hospital, and seven times more likely to have seen a nurse (Rochat et al. 2010). Signs of frailty are an indicator that something is wrong, so any health service interactions are an opportunity. Spotting and acting on early signs can help avert hospitalisation, nursing home admission, disability, and death (Section 9).

Take walking speed and its relationship with death. Stanaway et al. (2011a) found that even a simple measure like walking speed was predictive of death and that CHAMP men who walked faster were less likely to die, setting a benchmark for fitness goals.

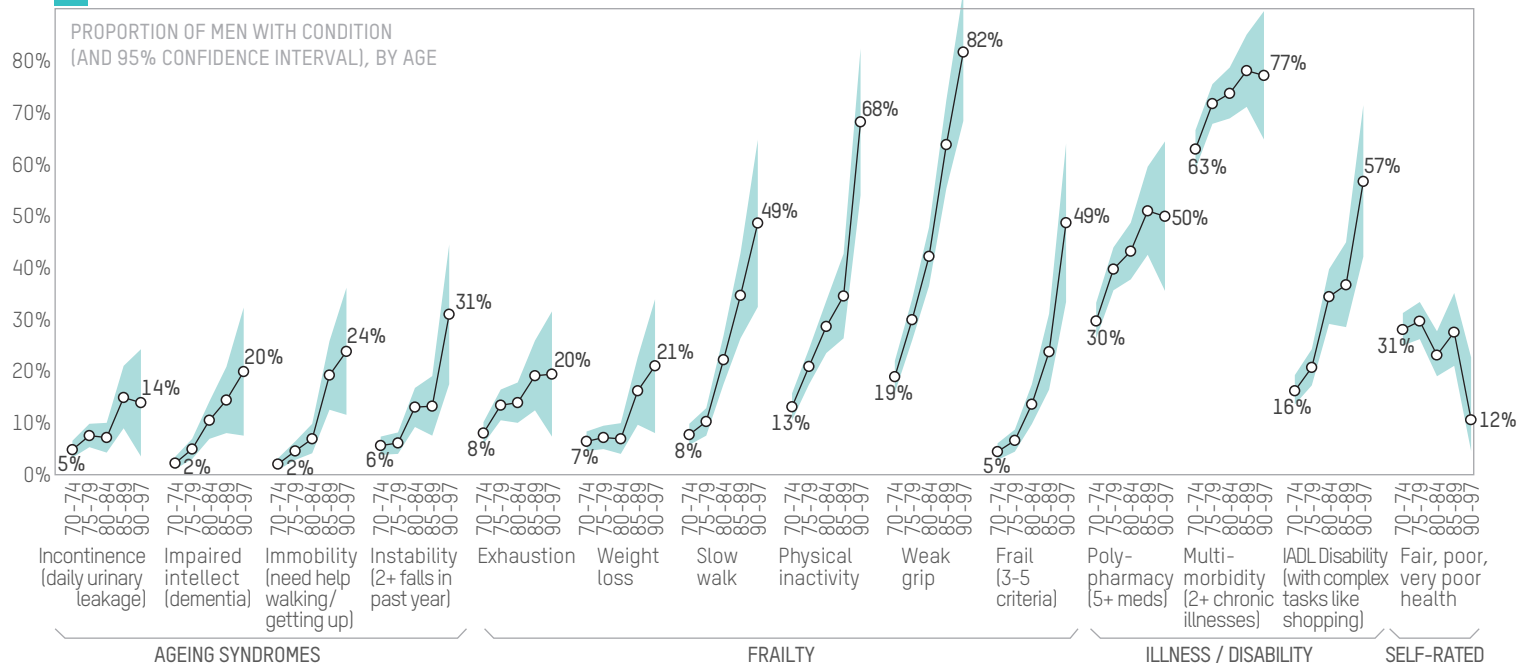
A health service responding to single diseases may be inadequate when caring for an older population. Hsu et al. (2020) found that frail men were more likely to have 13 of 14 cause-related hospital admissions. And Held et al. (2016) found that 75% of older men had multimorbidity (2+), with several identifiable morbidity clusters (Fig. 4). Health services and researchers need a wider lens, countering age-related health complications on multiple fronts.

### 4 MULTIPLE FRONTS: CO-OCCURRING CONDITIONS



Note: Based on CHAMP sample of community-dwelling older men. Source: Held et al. 2016

### 3 ACCUMULATING DEFICITS: THE TRAJECTORY OF AGEING AND DECLINE TO WATCH OUT FOR



Note: IADL denotes Instrumental Activities of Daily Living (e.g., shopping, doing finances etc.). Source: Noguchi et al. 2016. Self rated health from Khalatbari Soltani, unpublished

### 3. DEGENERATION OF MUSCLES AND BONES

It is common to lose muscle and gain fat as we age. Waist circumference typically increases in middle age, as does BMI, particularly for men (AIHW 2015). These peak around age 75, as weight gain turns to weight loss. In late age the loss of lean mass, comprising muscles and bones, is accompanied by the loss of fat, too.

The CHAMP team confirmed this in Bleicher et al. (2011a), based on the first two years of data. Older men lost about a quarter kilo of weight per year on average and this accelerated with age. Those gaining weight tended to gain fat, and those losing weight lost both lean mass and fat. They also found that fat loss was associated with bone weakness (i.e., lower density), more so than loss of muscle.

Indeed, in old age, fat may be related to good health, in what is known as the *obesity paradox*. On the one hand, CHAMP research suggests that obesity among older men increases the risk of heart disease, stroke, and diabetes (Scott et al. 2018). Yet, for those with healthy muscle mass, obese men were half as likely as non-obese men to enter an aged care home in the following nine years (Hirani et al. 2017). And that's not because they die before needing care: carrying extra fat is also linked to lower mortality (Hirani et al. 2014).

Where weight loss is an objective, CHAMP research suggests that maintaining muscle is paramount. Scott et al (2020) looked at the effect of changes in men's body composition on function, falls, and fractures in the following seven years. They find that losing fat could reduce the rate of falls by a quarter but losing muscle could increase this by three quarters. What's more, older men who lose muscle faster than fat see worse physical function (e.g., slower walking speed) and a higher risk of fractures.

Sarcopenia refers to muscle loss. It is thought to be part of a spiral, where age-related declines in muscle are exacerbated by disease, injury, inactivity, malnutrition, and further muscle loss. Sarcopenia can be defined as low muscle mass (e.g., lean mass in legs and arms, adjusted for height), strength (e.g., grip), or muscle quality (e.g., grip strength per muscle mass). Measures of sarcopenia also rely on measuring physical function (e.g., walking speed).

Changing definitions and cut-offs result in different case counts (as can measurement techniques; Mitchell et al. 2010). For example, Hirani et al. (2015a) found that at baseline, 14% of CHAMP men had low muscle mass (<20kg); 5% had low muscle mass *and* weak grip (<26kg), and 4% had these *plus* low walking speed (<0.8m/s).

To test which measures of sarcopenia affect daily living, Hairi et al. (2010) compared how indicators of sarcopenia relate to physical limitations (Fig. 5). They found that the strength of one's grip and quad strength were most telling.

Intervening in the sarcopenia cycle might be the key. Hirani et al. (2015b), found that sarcopenic older men were up to 4.5 times more likely to become disabled within five years, up to 2.5 times more likely to enter an aged care home, and 1.7 times more likely to die within nine years.

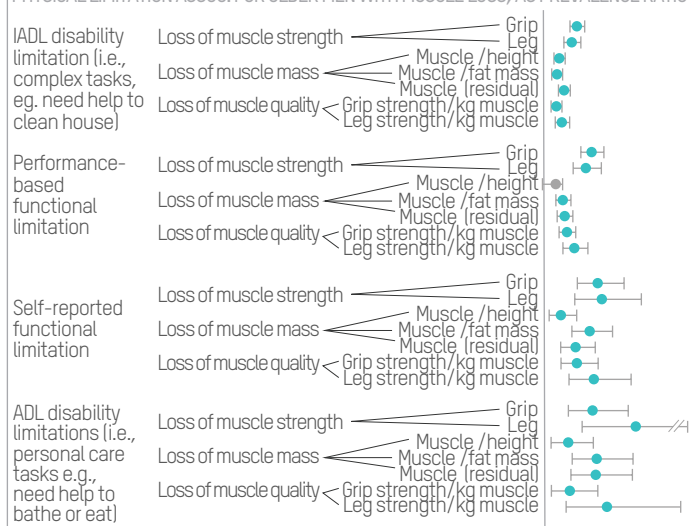
The team also investigated coexisting conditions. Scott et al. (2017) studied sarcopenic obesity, which can be easily missed without testing but makes up 7% of older men. And Scott et al. (2019) focused on low muscle mass *and* low bone density (termed by some as *osteosarcopenia*), which in theory could result in greater falls and fractures. Yet results suggest that men with both conditions had no worse outcomes than those with either condition alone, questioning osteosarcopenia as a separate disease entity.

As with muscles, bone strength tends to decline with age leading to osteoporosis in both men and women. Yet many don't realise they may have osteoporosis until a fragility fracture occurs. According to CHAMP data, a quarter of older men qualified for osteoporosis medications based on their bone density or presence of a fragility fracture. Of them, only 10% were on anti-osteoporosis medications (e.g. bisphosphonates; Bleicher et al. 2010).

In Bleicher (2011a and 2013) and Ng (2020), CHAMP researchers identify a range of factors associated with bone health. For example, engaging in high loading activities, like tennis, was associated with higher bone mineral density (Fig. 6), but not necessarily reduced incident falls and fractures.

#### 5 MUSCLES: STRENGTH A GOOD INDICATOR OF FUNCTION

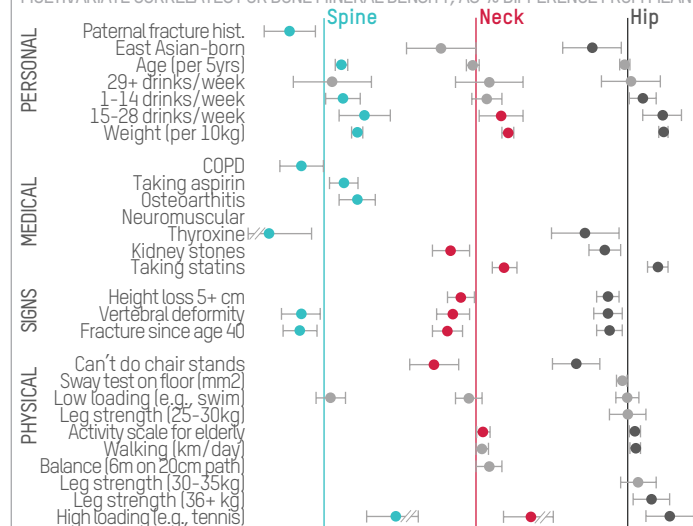
PHYSICAL LIMITATION ASSOC. FOR OLDER MEN WITH MUSCLE LOSS, AS PREVALENCE RATIO



Note: Greyed-out dots denote no statistical significance. ADL denotes Activities of Daily Living. Chart compares muscle loss prevalence in those with physical limitation to muscle loss prevalence in those without limitation. Loss is being in bottom quintile of muscle mass. Muscle mass is arm & leg lean mass. Unadjusted model. Source: Hairi et al. 2010

#### 6 BONES: ACTIVITY LEVEL MORE RELEVANT THAN AGE

MULTIVARIATE CORRELATES FOR BONE MINERAL DENSITY, AS % DIFFERENCE FROM MEAN



Note: Coefficients here show jointly estimated relationship between a unit change in each variable and % difference in bone mineral density from mean, for older community-dwelling men. Discrete variable unit is a dummy of 1, ref is 0. Source: Bleicher et al. 2011b

## 4. INADEQUATE NUTRITION

A poor diet, along with inadequate exercise, is one of the more controllable health risk factors. Eating well becomes more important as the body becomes less efficient in utilising nutrients and more vulnerable to health complications.

Nonetheless, intake of key nutrients among community-dwelling older people is often lacking. CHAMP data based on validated diet histories of men aged 75+ shows that while the majority were getting enough protein, iron, zinc, and vitamin B2, as many as 99% and 80% were consuming inadequate amounts of Vitamin D and calcium (Fig. 7; Waern et al. 2015). This is perhaps unsurprising, since most don't consume enough dairy (or alternatives). The majority also don't eat enough fruit and vegetables and 99% consume less than the recommended 2-6 litres of fluid per day. All the while, most consumed above the recommended amount of unsaturated fat and sugar (Ribeiro et al. 2017).

Those straying further from national dietary guidelines were more likely to have lower education, income, and physical activity. They were also more likely to be smokers, have higher waist-hip ratios, and experience frailty symptoms.

Interestingly, despite having worse guideline compliance, men with Mediterranean backgrounds did not have worse health outcomes, which indicates that Mediterranean diets may be healthier than existing national guidelines and that such guidelines may need further refinement.

The divergence between Mediterranean and guideline diets may also be why ethnic background is related to apparent 'declines' in diet quality over time (Fig. 8, left panel). Of interest to aged care home support providers is the fact that worsening diets are also associated with receiving meal services (though causality is not clear).

To test the effects of nutrient deficiency as well as of compliance with official guidelines and/or a typical Mediterranean diet, CHAMP researchers looked at the associated risk of sarcopenia. They found that poor diets, as scored against each of these benchmarks, were related to a greater chance of having sarcopenia. For example, men in the bottom quarter of intake of protein, magnesium, calcium, and omega-6 and -3 were two

three times more likely to have sarcopenia (Fig. 8, right panel). Notably, the association applied to only one of three different definitions of the disease, which attests to ongoing debates about its precise diagnosis.

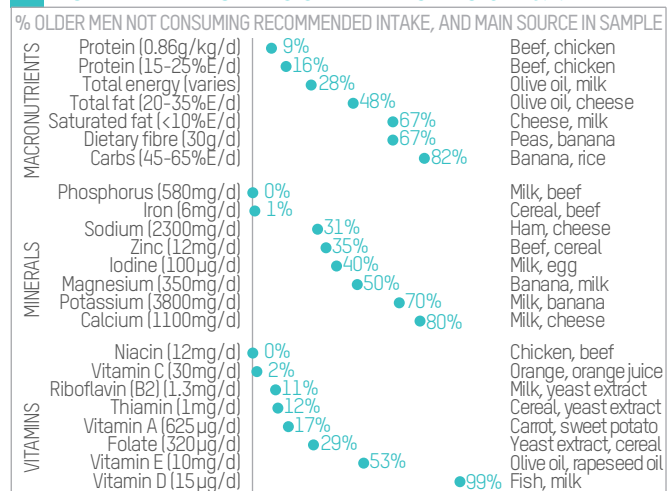
Studies have tested various characteristics of older men's eating habits. For example, Cervo et al. (2020) found that pro-inflammatory diets (e.g., those low in green vegetables) can result in presence of inflammation biomarkers in the blood that are in turn associated with less muscle and more falls in follow up assessments. Meanwhile, Das et al. (2020c) found that diets low in antioxidants (particularly Vitamin E) were related to doubling the future risk of frailty.

The team also measured Vitamin D levels in the blood. This vitamin is unique in that it can be synthesized by the human body based on sun exposure. Hirani et al. (2013) found that 55% of older men had insufficient Vitamin D blood levels in winter. But even in summer – in a sunny city like Sydney – about 37% weren't getting enough. Season, low physical activity, avoidance of sun exposure, smoking, and obesity were associated with low Vitamin D levels.

The likely implications of low Vitamin D are presented in a series of papers, suggesting that this is correlated with higher risks of sarcopenia (Hirani et al. 2018), diabetes (Hirani et al. 2014b), anaemia (Hirani et al. 2015b), disability, and death (Hirani et al. 2014c). Yet too much Vitamin D may be problematic too: those with lowest *and* highest levels had increased risk of fractures, not explained by physical activity levels or other factors (Bleicher et al. 2014).

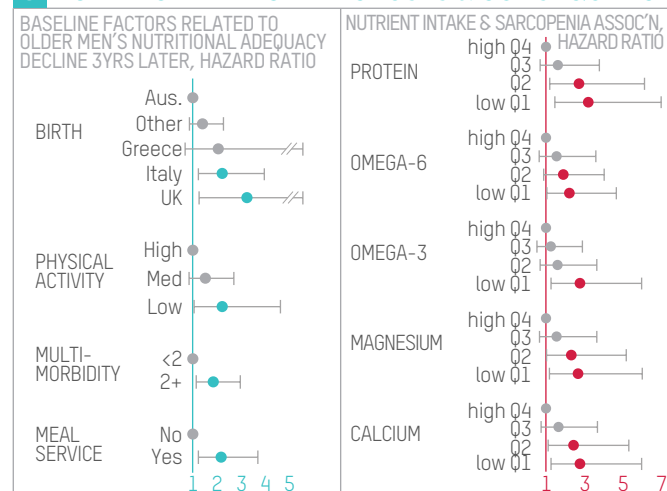
Finally, analyses of eating habits would be incomplete without looking at chewing. According to CHAMP data, about 15% of men aged 78+ had no teeth, with an average of 14 teeth missing and one tooth with active decay (Wright et al. 2018). The state of their oral health has a knock-on effect. Over one fifth found chewing uncomfortable and couldn't eat hard foods like carrots (Wright et al. 2019), which may increase the risk of depression (Wright et al. 2020). While the majority report annual dental check-ups and brushing twice a day, few floss or use mouthwash (Tran et al. 2019), and those with decay or gum disease rarely realise they need treatment (Takehara et al. 2020).

### 7 NUTRIENT LACK: TOO LITTLE CALCIUM & VITAMIN D



Note: Recommended intake in brackets. Men aged 75+ Source: Waern et al. 2015

### 8 NUTRITIONAL DECLINE: CAUSES & CONSEQUENCES?



Note: Men aged 75+ at baseline. Both panels show multivariate-adjusted results. Sarcopenia as per Foundation for National Institutes of Health definition. No association based on EWG definitions. Source: Das et al. 2020a. Das et al. 2020b

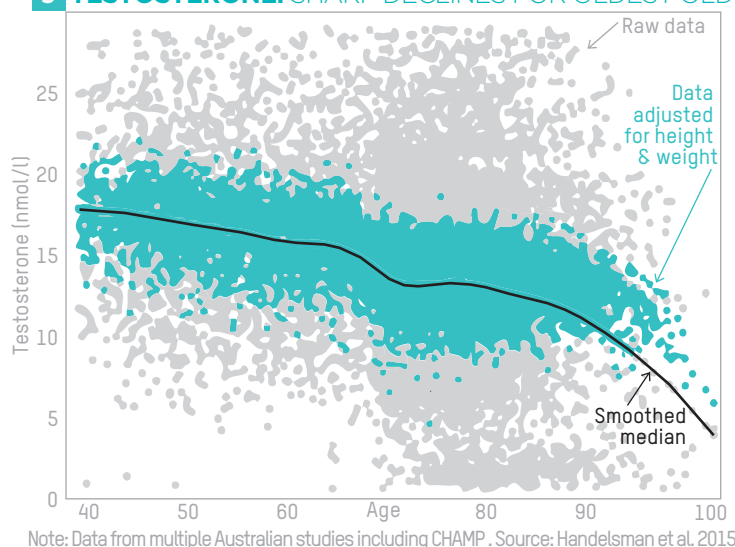


## 5. DECLINING HORMONE LEVELS

Biochemical shifts during ageing may be cause, consequence or coincidental of age-related deterioration. Of particular interest in studying men's ageing is the role of reproductive hormones such as testosterone, its metabolites, and its effects on the ageing of organs, tissues, and their functions. If reduced testosterone caused or accelerated age-related deterioration of organ or tissue function, then testosterone treatment could represent an opportunity to improve male health during ageing.

Blood testosterone levels of men decline at an average rate of 0.5% per year over middle to older age (Fig. 9) with lower testosterone levels among obese men and a faster decline at the oldest ages. For the CHAMP cohort, over the age of 70 years the decline is about 2-3% per year (Hsu et al. 2016a).

### 9 TESTOSTERONE: SHARP DECLINES FOR OLDEST OLD



Changes in blood hormones can coincide with age-related changes. Hsu et al. (2015) found that declines in self-reported sexual activity and desire (but not erectile dysfunction) were related to declines in blood testosterone. But the magnitude of change in blood testosterone was small, implying that sexual activity maintains blood testosterone level and that the decline in blood testosterone is the consequence rather than the cause of reduced sexual activity. This provides no basis for testosterone treatment of older men.

Hsu et al. (2014a, 2016b) found that loss of bone and risk of fracture coincided with changes in circulating reproductive hormones but not to testosterone itself. Hsu et al. (2014b) found that low blood testosterone predicted disability two years later; but these effects were due to parallel reductions in muscle mass and strength, not testosterone itself. More widely, studies reported in Travison et al. (2011) and Hsu et al. (2014c, 2014d, and 2016c) investigated frailty, metabolic syndrome, self-reported health, and mortality which were related to blood reproductive hormone levels but mostly by indirect relationships.

The studies offer a reminder that coincidence is not causation. Reproductive hormone declines coincide with age-related health issues. But CHAMP studies repeatedly show that hormone changes are more often the consequence rather than the cause of age-related impairments. They also highlight that there is a common mechanism causing both reproductive hormone decline and the deterioration of age-related function: the accumulation of comorbidities of ageing rather than ageing itself. CHAMP provides evidence to refute the idea of 'free' testosterone as a better measure of blood testosterone to predict age-related deterioration of male health. Similarly, the research provides no basis for the concept of a 'male menopause', that may be treated with testosterone therapy.

## 6. GREATER RELIANCE ON MEDICINES

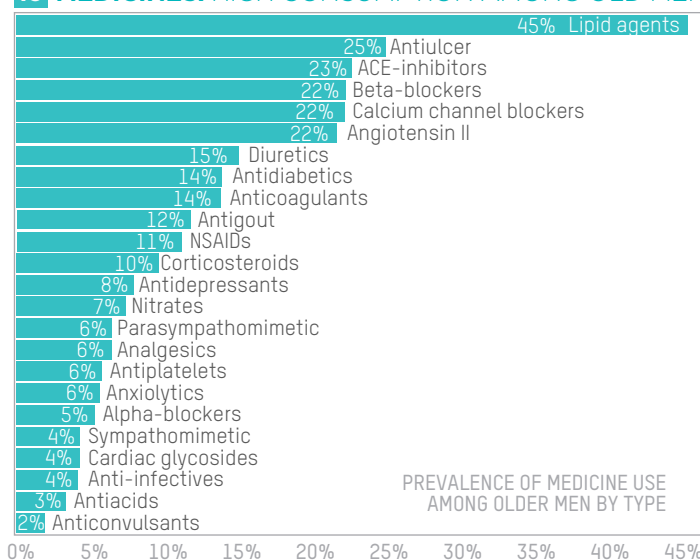
Old age can mean a greater reliance on medicines, with cholesterol-lowering drugs the most common (Fig. 10). In many cases, older men are missing out on the medicines they need. For instance, greater adherence to taking drugs for heart disease (particularly antiplatelets and statins) confers higher rates of survival (Gnjidic et al. 2015; also see Section 3 on osteoporosis).

But there is also a risk with taking lots of medications. Gnjidic et al. (2009, 2012a, 2012b, 2014a) estimated the impact of poly- and hyper-pharmacy (5+ and 10+ meds) and exposure to sedative and anticholinergic medications on functional outcomes. They found that high-risk prescribing was related to increased frailty, worse physical function (e.g., slow walk and weak grip) and disability, even after controlling for alternative explanations, including comorbidities. And Jansen et al. (2016) estimated that each additional medication was associated with 22% greater risk of moving from a robust state to death. And Gnjidic et al. (2012d) made use of functional and mortality outcomes to suggest that the risks increase above five medications.

In some cases, community-dwelling men are taking medications against advice. For example, Gnjidic et al. (2014) find that the majority of those using nonsteroidal anti-inflammatory drugs (NSAIDs eg. ibuprofen) are using them for too long (many years at a time), instead of the

recommended short-term usage. And few are taking action to protect their stomach when taking NSAIDs. Some may self-medicate with alcohol or combine alcohol with prescription drugs. Ilomaki et al. (2013) found that there was no association between antidepressants and drinking, but that older men using sedative or anxiety drugs were 40% more likely to be daily drinkers, which could result in excess sedation and cross-dependence.

### 10 MEDICINES: HIGH CONSUMPTION AMONG OLD MEN



## 7. DIMINISHING SOCIAL PARTICIPATION

Engagement in society is important at any age. A reduced capacity to socialise and participate in work and leisure is an accepted aspect of disability. It also has a bearing on mental health. So how does participation in life change with age?

In Fairhall et al. (2014), CHAMP researchers tracked older men's decline in participation in life based on twenty items. These included the ability to go shopping, communicate, and do housework, and views about belonging and social relationships. Over just two years, half the men saw participation declines (a third saw improvements). A number of factors could predict low participation and decline. Some could be candidates for intervention, such as depression or compromised ability to walk or drive (Fig. 11).

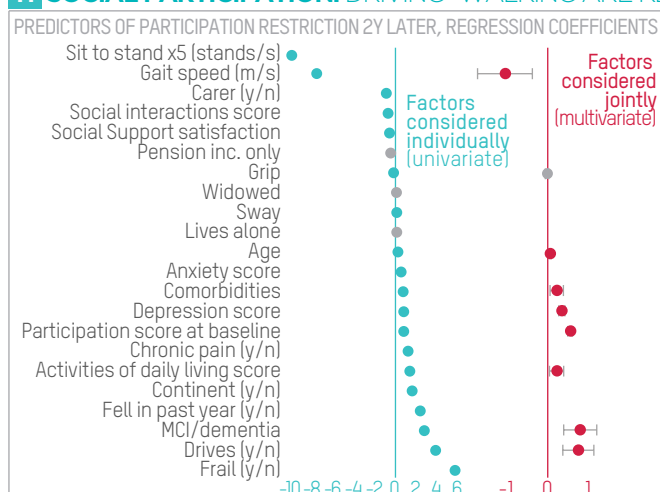
Another change relates to ones' social circle. Stanaway et al. (2010, 2011) found that actual and perceived level of social support can depend on ethnic background. Compared to older men born in Australia, migrants from Italy were much more likely to rely on family for support than on friends. About 4% had no local family and 34% had no local friends they could rely on, compared to 13% and 17% for the Australian-born population. Yet having family around did

not translate to feeling more emotionally supported overall for Italian migrants, even after controlling for other factors like health. This could be because they had greater culturally-based expectations of support (e.g., expectation of filial piety). The effect of non-family support on perceptions of overall support disappeared after the effect of depression was included. That is, those that feel less supported tend to have fewer friends as well as depression.

A lack of social support could be a driver of depression (Stanaway et al. 2010; Khalatbari-Soltani et al. 2021; Fig. 12). It may also be an added stressor affecting health. For example, while we know that poorer men have shorter lives, CHAMP data suggests that up to a third of these mortality differences could be explained by the fact that poorer men have weaker social relationships and greater rates of depression (Khalatbari-Soltani et al. 2020). That is, strong relationships may partly offset the health impacts of having low income.

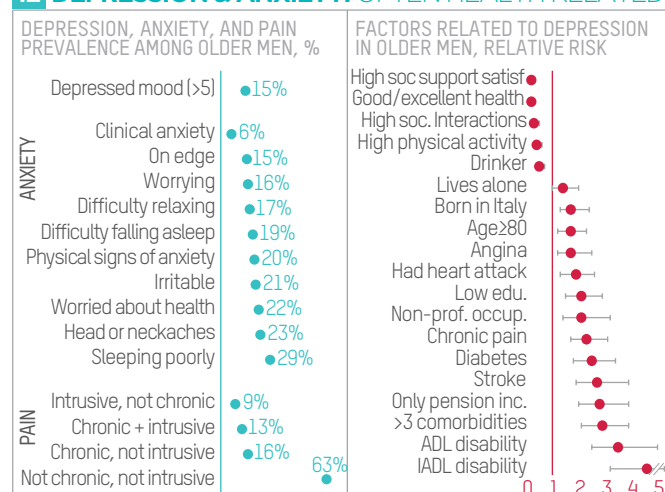
Older men can themselves be the source of support. About 11% were caring for their partner. The role had a limited effect on their health and mortality, but men who were carers report more anxiety related symptoms (Shu et al. 2017, 2019).

### 11 SOCIAL PARTICIPATION: DRIVING+WALKING ARE KEY



Note: Univariate results help us see the characteristics that someone at risk of participation restriction may present with. Multivariate results help us see which are most related to participation restriction. Source: Fairhall et al. 2014

### 12 DEPRESSION & ANXIETY: OFTEN HEALTH RELATED



Note: Right panel data based on subset of CHAMP men born in Australia or Italy only. Association based on univariate estimation. Health subjective. Source: Blyth et al. 2008, 2011. Stanaway et al. 2010

## 8. GREATER PREVALENCE OF PAIN

Pain results from potential or actual damage to bodies, and is a leading cause of disability around the world. Pain may become chronic (lasting longer than normal) or intrusive (interfering with daily activities). Biological, psychological and social factors are all involved in how pain is experienced by individuals.

For example, Stanaway et al. (2011) found that while back pain prevalence for both Italian- and Australian-born older men was about 60%, the former felt it more severely (severity was also higher for poorer men). Socioeconomic status also influenced the experience of back pain in the study.

For a quarter of older men, pain interferes with daily life (Blyth et al. 2008). For many, worry about health, particularly in presence of intrusive pain, had a negative psychological effect (Blyth et al. 2011).

Of course, pain is a signal to the body that something is wrong. This signal may point to conditions in addition to those causing pain. Intrusive pain can signal the presence of current frailty and comorbidity while chronic pain can be a risk marker of frailty in the future (Megale et al. 2018). Take chronic knee pain, for example. Fransen et al. (2014) found that about 40% of older men had knee pain, which raised the risk of future loss of muscle, higher mobility disability, and falls. Importantly, such an outcome may be preventable: greater quad strength and a healthy weight were protective of subsequently developing knee pain.

Hirani et al. (2015c) report that low levels of vitamin D metabolites in the blood of older men was associated with 50% higher odds of chronic pain, even after adjustment for potential confounders. Exercise, good nutrition, and getting out in the sun may help keep pain in check.

## 9. INJURY, ILLNESS, AND MORTALITY

About 1,000 of the CHAMP men first assessed in 2005 have since passed away. About 700 are still alive. While many of those who developed health complications and died were older than those that survived, age is not the only predictor of a decline in function that manifests in injury, aged care need, illness, and ultimately death.

Falls are a key symptom of ageing. About 5% of falls lead to fractures, but even falls without injury can lead to loss of confidence, future falls (Fig. 13), and moving to a care home. The CHAMP team identified novel risk factors for falls. Noguchi et al. (2016b) found that having urgency related incontinence doubled the fall rate; Stanaway et al. (2011d) found that Italian migrants had 40% fewer falls, even after accounting for other explanations; and Merom et al. (2014) found that regular swimming was protective against falls.

But physical and cognitive fitness play the most important part in protecting against falls. A quarter of CHAMP men that had dementia at baseline went on to fall three or more times by the two-year follow-up (compared to 6% for those with normal cognition). Indeed, even adjusting for other factors, like bone strength, reveals that those with dementia had more than four times the risk of hip fracture (Hsu et al. 2018a).

A minority of older men can expect to move into an aged care home in late life. Over the first seven years of the sample, about 7% of CHAMP men did so (Gnjidic 2012d). Again, physical factors, such as low grip strength and disability, were predictive of needing care. But the most important factor was cognition. Interestingly, Mild Cognitive Impairment (MCI) was unrelated to short-term care need yet it predicted moving into care in the medium term (Fig. 14).

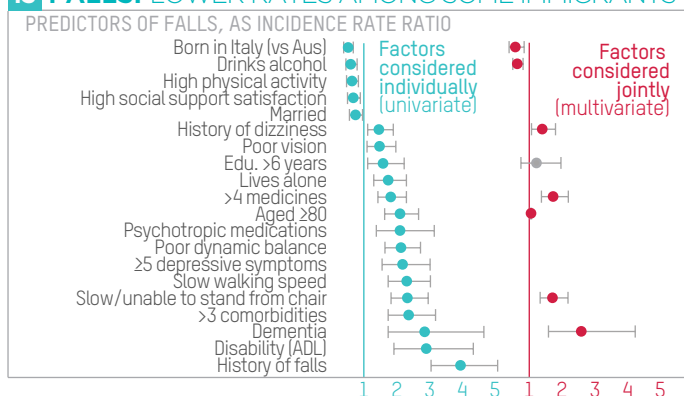
While dementia is often most feared, cancers still cause the greatest burden of disease and death in Australia. The key strategy of reducing its impact is targeting preventable factors where the association is strong and exposure is common: smoking, drinking, and obesity. Researchers from the *Australian cancer-PAF cohort consortium* pooled datasets, including CHAMP, to quantify the potential for easing this burden (Laaksonen 2018, 2020, Vajdic 2018, Arriaga 2017, 2019). For example, they estimated that about a quarter of cancers could be avoided with a long-term elimination of smoking and reduced drinking (Fig. 15).

Of the many signs of ageing, which are most predictive of a decline toward death? Identifying these can prove useful in making clinical decisions and designing interventions. Hirani et al. 2014a suggest that predictors include low BMI, smoking, heart disease, cancer, depression, and disability (Fig. 16; see also Section 7 on social factors).

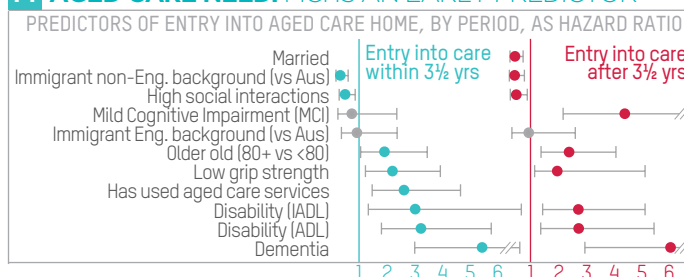
But CHAMP allows us to also see novel connections. Hsu et al. (2017) focused on sexual function: 64% of older men had erectile dysfunction at baseline and 56% were sexually inactive. Levels or changes in these predicted death years later, though not independently of depression symptoms, suggesting that desire may decline alongside other ills rather than cause them. And Hsu et al. (2018b) found that participating in strenuous sports, increasing walking speed, or muscle strengthening appeared to lower the chance of dying. Not so for light or moderate activity.

The good news is that many older men report good health, function, and quality of life despite any health problems (Fig 3). The challenge is to make sure more people feel the same.

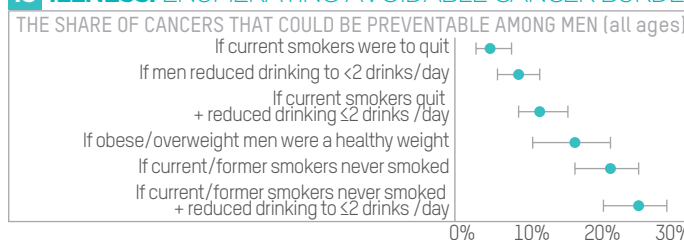
### 13 FALLS: LOWER RATES AMONG SOME IMMIGRANTS



### 14 AGED CARE NEED: MCI IS AN EARLY PREDICTOR



### 15 ILLNESS: ENUMERATING AVOIDABLE CANCER BURDEN



### 16 DEATH: SOME PREDICTORS ARE BETTER THAN OTHERS



Note: Incidence and hazard ratios compare rate of given occurrence for older men with given characteristic with those without it (e.g., immigrants compared to Aust. born, drinking compared to normal drinking 1-21 drinks/week). Fig. 13 data based on CHAMP data of Italian-born and Aust. born men. Fig. 15 based on CHAMP and other data. Source: Stanaway et al. 2011d; Gnjidic et al. 2012d; Arriaga et al. 2017; Hirani et al. 2014a



# REFERENCES

- ABS [2016] Australian Population Census
- AIHW [2015] A picture of overweight and obesity in Australia
- Ariaga et al. [2017] The burden of cancer attributable to modifiable risk factors: The Australian cancer-PAF cohort consortium. *BMJ open*, 7(6) e016178
- Ariaga et al. [2019] The burden of pancreatic cancer in Australia attributable to smoking. *Medical J of Australia*, 210(5) 213-220
- Bleicher et al. [2010] Prevalence and treatment of osteoporosis in older Australian men: findings from the CHAMP study. *Medical J of Australia*, 193(7) 387-391
- Bleicher et al. [2011a] The role of fat and lean mass in bone loss in older men: Findings from the CHAMP study. *Bone*, 49(6) 1299-1305
- Bleicher et al. [2011b] Lifestyle factors, medications, and disease influence bone mineral density in older men: Findings from the CHAMP study. *Osteoporosis International*, 22(9) 2421-2437
- Bleicher et al. [2013] Predictors of the rate of BMD loss in older men: Findings from the CHAMP study. *Osteoporosis International*, 24(7) 1951-1963
- Bleicher et al. [2014] U-shaped association between serum 25-hydroxyvitamin D and fracture risk in older men: Results from the prospective population-based CHAMP study. *J of Bone and Mineral Research*, 29(9) 2024-2031
- Blyth et al. [2008] Pain, frailty and comorbidity on older men: The CHAMP study. *Pain*, 140(1) 224-230
- Blyth et al. [2011] Intrusive pain and worry about health in older men: The CHAMP study. *PAIN*, 152(2) 447-452
- Cervo et al. [2020] Proinflammatory diet increases circulating inflammatory biomarkers and falls risk in community-dwelling older men. *The J of Nutrition*, 150(2) 373-381
- Cumming et al. [2009] Cohort profile: The Concord Health and Ageing in Men Project. *International J of epidemiology*, 38(2) 374-378
- Das et al. [2020a] Changes in micronutrient intake and factors associated with this change among older Australian men: The Concord Health and Ageing in Men Project. *Public Health Nutrition*, 1-12
- Das et al. [2020b] Associations between nutrient intakes and dietary patterns with different sarcopenia definitions in older Australian men: The Concord Health and Ageing in Men Project—ERRATUM. *Public health nutrition*, 1-6
- Das et al. [2020c] Prospective associations between dietary antioxidant intake and frailty in older Australian men: The Concord Health and Ageing in Men Project. *The J of Gerontology: Series A*, 75(2) 348-356
- Fairhall et al. [2014] Predicting participation restriction in community-dwelling older men: The Concord Health and Ageing in Men Project. *Age and ageing*, 43(1) 31-37
- Fransen et al. [2014] A longitudinal study of knee pain in older men: Concord Health and Ageing in Men Project. *Age and ageing*, 43(2) 206-212
- Gnjidic et al. [2009] Drug Burden Index and physical function in older Australian men. *British J of Clinical Pharmacology*, 68(1) 97-105
- Gnjidic et al. [2012a] Effects of drug burden index on cognitive function in older men. *J of Clinical Psychopharmacology*, 32(2) 273-277
- Gnjidic et al. [2012b] High-risk prescribing and incidence of frailty among older community-dwelling men. *Clinical Pharmacology & Therapeutics*, 91(3) 521-528
- Gnjidic et al. [2012c] Polypharmacy cut off and outcomes: Five or more medicines were used to identify community-dwelling older men at risk of different adverse outcomes. *J of Clinical Epidemiology*, 65(9) 989-995
- Gnjidic et al. [2012d] Mild cognitive impairment predicts institutionalization among older men: a population-based cohort study. *PLOS ONE*, 7(9) e40601
- Gnjidic et al. [2014a] Sedative load and functional outcomes in community-dwelling older Australian men: The CHAMP study. *Fundamental & Clinical Pharmacology*, 28(1) 10-19
- Gnjidic et al. [2014b] Nonsteroidal anti-inflammatory drugs (NSAIDs) in older people: Prescribing patterns according to pain prevalence and adherence to clinical guidelines. *PAIN*, 155(9) 1814-1820
- Gnjidic et al. [2015] Ischemic heart disease, prescription of optimal medical therapy and geriatric syndromes in community-dwelling older men: A population-based study. *International J of cardiology*, 192, 49-55
- Handelsman et al. [2015] Age-specific population centiles for androgen status in men. *Eur J Endocrinol*, 173(6) 809-817
- Held et al. [2016] Association rules analysis of comorbidity and multimorbidity: The Concord Health and Ageing in Men Project. *J of Gerontology Series A: Biomedical Sciences and Medical Sciences*, 71(5) 625-631
- Held et al. [2017] Polypharmacy in older adults: Association Rule and Frequent-Set Analysis to evaluate concomitant medication use. *Pharmacological Research*, 116, 39-44
- Hairi et al. [2010] Loss of muscle strength, mass (sarcopenia) and quality (specific force) and its relationship with functional limitation and physical disability: The Concord Health and Ageing in Men Project. *J of the American Geriatrics Society*, 58(11) 2055-2062
- Hirani et al. [2013] Vitamin D status among older community dwelling men living in a sunny country and associations with lifestyle factors: The Concord Health and Ageing in Men Project, Sydney, Australia. *The J of nutrition, health & aging*, 17(7) 587-593
- Hirani et al. [2014a] Multiple, but not traditional risk factors predict mortality in older people: The Concord Health and Ageing in Men Project. *Age*, 36(6) 9732
- Hirani et al. [2014b] Low levels of 25-hydroxy vitamin D and active 1, 25-dihydroxyvitamin D independently associated with type 2 diabetes mellitus in older Australian men: The Concord Health and Ageing in Men Project. *J of the American Geriatrics Society*, 62(9) 1741-1747
- Hirani et al. [2014c] Associations between serum 25-Hydroxyvitamin D concentrations and multiple health conditions, physical performance measures, disability, and all-cause mortality: The Concord Health and Ageing in Men Project. *J of the American Geriatrics Society*, 62(3) 417-425
- Hirani et al. [2015a] Sarcopenia is associated with incident disability, institutionalization, and mortality in community-dwelling older men: The Concord Health and Ageing in Men Project. *J of the American Medical Directors Association*, 16(7) 607-613
- Hirani et al. [2015b] Cross-sectional and longitudinal associations between the active vitamin D metabolite (1, 25 dihydroxyvitamin D) and haemoglobin levels in older Australian men: The Concord Health and Ageing in Men Project. *Age*, 37(1) 8
- Hirani et al. [2015c] Active vitamin D (1, 25 dihydroxyvitamin D) is associated with chronic pain in older Australian men: The Concord Health and Ageing in Men Project. *J of Gerontology Series A: Biomedical Sciences and Medical Sciences*, 70(3) 387-395
- Hirani et al. [2017] Longitudinal associations between body composition, sarcopenic obesity and outcomes of frailty, disability, institutionalisation and mortality in community-dwelling older men: The Concord Health and Ageing in Men Project. *Age and Ageing*, 46(3) 413-420
- Hirani et al. [2018] Longitudinal associations between vitamin D metabolites and sarcopenia in older Australian men: The Concord Health and Ageing in Men Project. *The J of Gerontology: Series A*, 73(1) 131-138
- Holden et al. [2005] Men in Australia Telephone Survey (MATES): A national survey of the reproductive health and concerns of middle-aged and older Australian men. *Lancet*, 366(9481) 218-24
- Hsu et al. [2014a] Longitudinal relationship between reproductive hormones and total hip bone loss and hip fractures among community-dwelling older men: The Concord Health and Ageing in Men Project. *In Endocrine Reviews* (Vol. 35, No. 3)
- Hsu et al. [2014b] Longitudinal relationships of circulating reproductive hormone with functional disability, muscle mass, and strength in community-dwelling older men: The Concord Health and Ageing in Men project. *The J of Clinical Endocrinology & Metabolism*, 99(9) 3310-3318
- Hsu et al. [2014c] Associations between circulating reproductive hormones and SHBG and prevalent and incident metabolic syndrome in community-dwelling older men: The Concord Health and Ageing in Men Project. *The J of Clinical Endocrinology & Metabolism*, 99(12) E2686-E2691
- Hsu et al. [2014d] Longitudinal and cross-sectional relationships of circulating reproductive hormone levels to self-rated health and health-related quality of life in community-dwelling older men. *The J of Clinical Endocrinology & Metabolism*, 99(5) 1638-1647
- Hsu et al. [2015] The longitudinal relationship of sexual function and androgen status in older men: The Concord Health and Ageing in Men Project. *The J of Clinical Endocrinology & Metabolism*, 100(4) 1350-1358
- Hsu et al. [2016a] Temporal trend in androgen status and androgen-sensitive outcomes in older men. *The J of Clinical Endocrinology & Metabolism*, 101(4) 1836-1846
- Hsu et al. [2016b] Progressive temporal change in serum SHBG, but not in serum testosterone or estradiol, is associated with bone loss and incident fractures in older men: The Concord Health and Ageing in Men Project. *J of Bone and Mineral Research*, 31(12) 2115-2122
- Hsu et al. [2016c] Temporal changes in androgens and estrogens are associated with all-cause and cause-specific mortality in older men. *The J of Clinical Endocrinology & Metabolism*, 101(5) 2201-2210
- Hsu et al. [2017] Sexual function and mortality in older men: The Concord Health and Ageing in Men Project. *J of Gerontology Series A: Biomedical Sciences and Medical Sciences*, 72(4) 520-527
- Hsu et al. [2018a] Community-dwelling older men with dementia are at high risk of hip fracture, but not any other fracture: The Concord Health and Ageing in Men Project. *Geriatrics & Gerontology International*, 18(10) 1479-1484
- Hsu et al. [2018b] Total physical activity, exercise intensity, and walking speed as predictors of all-cause and cause-specific mortality over 7 years in older men: The Concord Health and Ageing in Men Project. *J of the American Medical Directors Association*, 19(3), 216-222
- Hsu et al. [2020] Frailty and cause-specific hospitalizations in community-dwelling older men. *The J of Nutrition, Health & Aging*, 1-7
- Ilomäki et al. [2013] Psychotropic drug use and alcohol drinking in community-dwelling older Australian men: The CHAMP study. *Drug and Alcohol Review*, 32(2) 218-222
- Jansen et al. [2016] Effects of changes in number of medications and drug burden index exposure on transitions between frailty states and death: The Concord Health and Ageing in Men Project. *J of the American Geriatrics Society*, 64(1) 89-95
- Khalatbari-Soltani et al. [2020] Socioeconomic status, health-related behaviours, and death among older people: The Concord health and aging in men project prospective cohort study. *BMC Geriatrics*, 20(1) 1-14
- Khalatbari-Soltani et al. [2021] The association between home ownership and the health of older men: Cross-sectional analysis of the Australian Concord Health and Ageing in Men Project. *Australasian J of Ageing*
- Laaksonen et al. [2018] The future burden of lung cancer attributable to current modifiable behaviours: a pooled study of seven Australian cohorts. *International J of Epidemiology*, 47(6) 1772-1783
- Laaksonen et al. [2020] The future burden of kidney and bladder cancers preventable by behavior modification in Australia: A pooled cohort study. *International J of Cancer*, 146(3) 874-883
- Megale et al. [2018] Association between pain and the frailty phenotype in older men: longitudinal results from the Concord Health and Ageing in Men Project. *Age and Ageing*, 47(3) 381-387
- Merom et al. [2014] Swimming and other sporting activities and the rate of falls in older men: Longitudinal findings from the Concord Health and Ageing in Men Project. *American J of Epidemiol*, 180(8) 830-837
- Mitchell et al. [2010] Estimation of lean body weight in older community-dwelling men. *British J of Clinical Pharmacology*, 69(2) 118-127
- Ng et al. [2020] Higher impact physical activity is associated with maintenance of bone mineral density but not reduced incident falls or fractures in older men: CHAMP. *J Bone Miner Res*.
- Noguchi et al. [2016a] Prevalence of the geriatric syndromes and frailty in older men living in the community: The Concord Health and Ageing in Men Project. *Australasian J on Ageing*, 35(4) 255-261
- Noguchi et al. [2016b] A systematic review of the association between lower urinary tract symptoms and falls, injuries, and fractures in community-dwelling older men. *The Aging Male*, 19(3) 168-174
- Ribeiro et al. [2017] Diet quality and its implications on the cardio-metabolic, physical and general health of older men: The Concord Health and Ageing in Men Project. *British J of Nutrition*, 118(2) 130-143
- Rochat et al. [2010] Frailty and use of health and community services by community-dwelling older men: The Concord Health and Ageing in Men Project. *Age and Ageing*, 39(2) 228-233
- Scott et al. [2017] Sarcopenic obesity and its temporal associations with changes in bone mineral density, incident falls, and fractures in older men: The Concord Health and Ageing in Men Project. *J of Bone and Mineral Research*, 32(3) 575-583
- Scott et al. [2018] Associations of sarcopenic obesity with the metabolic syndrome and insulin resistance over five years in older men: The Concord Health and Ageing in Men Project. *Experimental gerontology*, 108 99-105
- Scott et al. [2019] Does combined osteopenia/osteoporosis and sarcopenia confer greater risk of falls and fracture than either condition alone in older men? The Concord Health and Ageing in Men Project. *The J of Gerontology: Series A*, 74(6) 827-834
- Scott et al. [2020] Associations of body composition trajectories with bone mineral density, muscle function, falls, and fractures in older men: The Concord Health and Ageing in Men Project. *The J of Gerontology: Series A*, 75(5) 939-945
- Shu et al. [2017] Health status, health behaviours and anxiety symptoms of older male caregivers: Findings from the Concord Health and Ageing in Men Project. *Australasian J on Ageing*, 36(2) 151-157
- Shu et al. [2019] Caregiving and all-cause mortality in older men 2005-15: The Concord Health and Ageing in Men Project. *Age and Ageing*, 48(4) 571-576
- Stanaway et al. [2010a] Depressive symptoms in older male Italian immigrants in Australia: The Concord Health and Ageing in Men Project. *Medical J of Australia*, 192(3) 158-162
- Stanaway et al. [2011a] How fast does the Grim Reaper walk? Receiver operating characteristics curve analysis in healthy men aged 70 and over. *BMJ*, 343, d7679
- Stanaway et al. [2011b] Subjective social support in older male Italian-born immigrants in Australia. *J of Cross-Cultural Gerontology*, 26(2) 205-220
- Stanaway et al. [2011c] Back pain in older male Italian-born immigrants in Australia: The importance of socioeconomic factors. *European J of Pain*, 15(1) 70-76
- Stanaway et al. [2011d] Ethnicity and falls in older men: Low rate of falls in Italian-born men in Australia. *Age and ageing*, 40(5) 595-601
- Stanaway et al. [2020] Mortality paradox of older Italian-born men in Australia: The Concord Health and Ageing in Men Project. *J of Immigrant and Minority Health*, 22(1) 102-109
- Takehara et al. [2020] A cross-sectional study of perceived dental treatment needs and oral health status in community-dwelling older Australian men: The Concord Health and Ageing in Men Project. *International dental J*
- Tran et al. [2019] Oral health behaviours of older Australian men: The Concord Health and Ageing in Men Project. *Australian dental J*, 64(3) 246-255
- Travisson et al. [2011] Changes in reproductive hormone concentrations predict the prevalence and progression of the frailty syndrome in older men: The Concord Health and Ageing in Men Project. *The J of Clinical Endocrinology & Metabolism*, 96(8) 2464-2474
- Vajdic et al. [2018] The future colorectal cancer burden attributable to modifiable behaviors: A pooled cohort study. *JNCI Cancer Spectrum*, 2(3) pky033
- Waern et al. [2015] Adequacy of nutritional intake among older men living in Sydney, Australia: Findings from the Concord Health and Ageing in Men Project. *British J of Nutrition*, 114(5) 812-821
- Wright et al. [2018] Oral health of community-dwelling older Australian men: The Concord Health and Ageing in Men Project. *Australian Dental J*, 63(1) 55-65
- Wright et al. [2019] Chewing function, general health and the dentition of older Australian men: The Concord Health and Ageing in Men Project. *Community Dentistry and Oral Epidemiology*, 47(2) 134-141
- Wright et al. [2020] Associations between oral health and depressive symptoms: Findings from the Concord Health and Ageing in Men Project. *Australasian J on Ageing*