Correlation of a Whole Foods Plant-Based Diet and Coronary Artery Disease

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Abstract:

Whole-foods plant-based diets (WFPBD) have surged in popularity secondary to the recognition that it is a healthier alternative to the standard Western diet which is characterised by high-intakes of animal-products. In recent years, research has suggested that a WFPBD offers an array of health benefits. This includes, but is not limited to, the reversal and prevention of chronic diseases such as coronary artery disease (CAD) *(Tuso et al., 2015).* Atherosclerosis, a main component in the pathogenesis of CAD has become associated with greater consumption of meats; red and processed meats in particular. Since the 1980s, medical professionals have revealed that WFPBDs were directly associated with improving atherosclerosis, thus leading towards the prevention and reversal of such a disease *(ibid.).* This report will examine to what extent the WFPBD prevents Australia's leading cause of death, CAD by analysing and interpreting clinal research studies and reports.

Introduction:

What is a WFPBD?

A WFPBD is a dietary pattern whereby the focus is placed on eating predominantly plant-derived foods. Dependent on the extent of animal-product consumption, plant-based diets can vary greatly amongst individuals. Nevertheless, all WFPBDs abide by a set of essential principles *(McManus, 2018)*:

- Emphasis on whole unprocessed foods.
- Reducing consumption of animal-products.
- Emphasis on plant-based products such as vegetables, fruits, whole grains, legumes, seeds and nuts.
- Exclusion of processed and refined foods such as white bread and added sugars.

WFPBDs have been studied to determine their impact on human physiology. WFPBDs may reverse hypertension and dyslipidaemia, increase heart and cognitive health, assist in maintaining a healthy weight and in lowering the risk of diabetes, certain cancers and stroke *(Lawler, 2020).* A common disadvantage associated with WFPBDs are nutritional deficiencies, namely vitamin B-12 & D, calcium and omega-3 fatty acids. However, these deficiencies can easily be prevented or treated with supplementation *(My, 2020).*

What is CAD?

Affecting an estimated 580,300 Australians, CAD is the dominant killer worldwide and is expected to surge to 187-million affected by 2030 *(Australian Institute of Health and Welfare, 2020).* CAD is a cardiovascular disease (CVD) where the coronary arteries (CA), which supply blood to the heart, are damaged/diseased. A major factor of CAD is plaque accumulation on the inner linings of the CA, a process known as atherosclerosis (see figure 1). When combined with inflammatory processes, they can significantly constrict the CA, restricting blood flow to the heart. This process can lead to life-threatening complications such as a heart attack *(Campbell, 2006) (Mandal, 2019).* Risk factors of CAD can be divided into two groups: modifiable (mRF) and non-modifiable risk factors (nmRF). mRF include hypertension, dyslipidaemia, smoking, diabetes, obesity and physical inactivity. nmRF include age, gender, genetics and ethnicity *(ibid.) (Bursill, 2020).* Those with nmRFs regardless of a healthy lifestyle and diet will always be pre-disposed to CAD. Clinical reviews have shown that in terms of mRFs, nutritional choices are most attributable to non-congenital cardiovascular diseases compared to other mRFs such as smoking and physical inactivity *(Prabhakaran et al., 2018)* (see figure 2). A prime example is the Western-diet; high in saturated-fats and cholesterol and known to positively-influence the onset and progression of CAD. Consequences of CAD including heart attack, can insidiously or immediately infringe an individual's quality of life or be life threatening *(American Heart Association, 2015).* To prevent/reduce CAD, a variety of lifestyle changes can be adopted. These include eliminating smoking, addressing conditions such as hypertension, dyslipidaemia, diabetes and obesity, ensuring adequate exercise and sourcing majority of nutrition from fruits, vegetables, nuts and wholegrains such as from a WFPBD *(Johns Hopkins Medicine, nd).* Of these changes, dietary modifications have been shown to more likely produce positive outcomes in patients *(ibid.).*

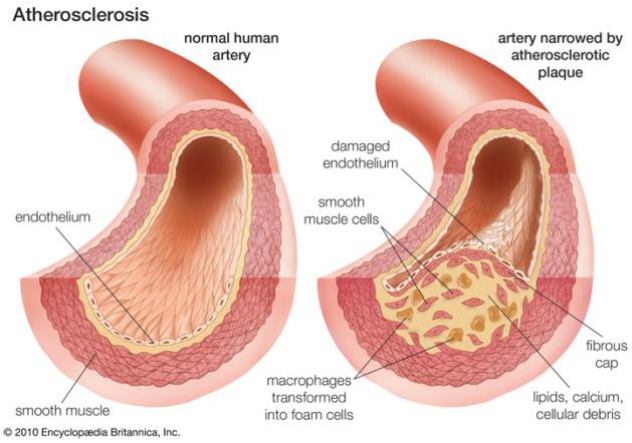

Figure 1: Diagram depicting atherosclerosis (Encyclopaedia Britannica, nd., pg. 1)

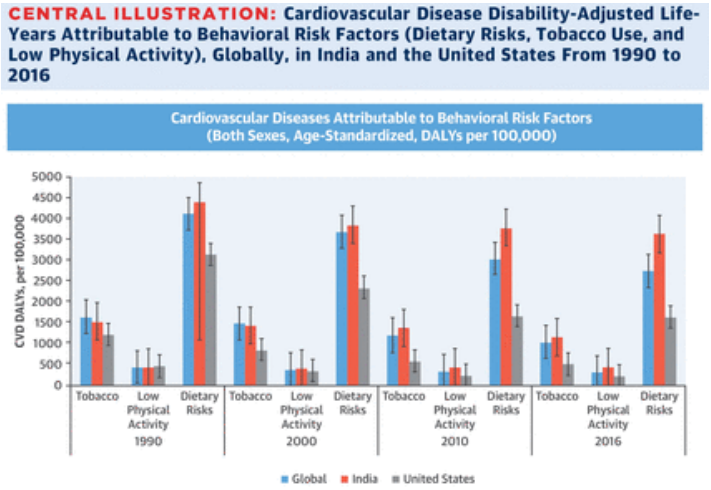

Figure 2: Vertical graph depicting weighting of mRFs attributable to CVD. (Prabhakaran et al., 2018, pg. 1)

Association between animal-products:

Saturated Fats (SFs) and Cholesterol:

Studies have shown that the association between diet and CAD is due to the high intake of SFs and cholesterol. High amounts of these components can increase low-density lipoprotein (LDL) and lower high-density lipoprotein (HDL) both of which are positively-correlated with CAD. LDL is associated with cholesterol build-up within arteries whereas HDL transports cholesterol to the liver where it can be broken down and removed *(Heart Organisation, nd).* As seen in Figure 3, 64% of SF intake in the UK derives from animal-products. Animal-products contain high amounts of SFs and cholesterol which readily accumulate within the CA as "plaque", thus impairing blood circulation *(WebMD, nd*). This process is referred to as atherosclerosis which is a major predecessor for CAD. The Framingham Heart Study, in which experimental animals were fed a diet high in SFs and cholesterol diet and concluded that these components were heavily associated with CAD

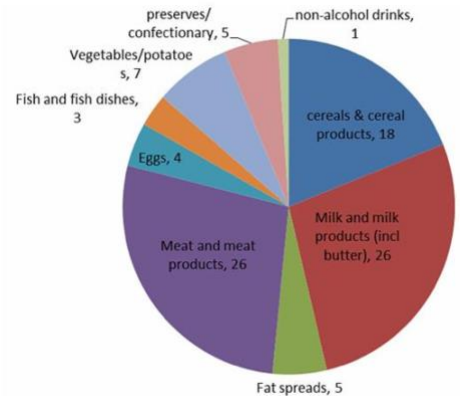

Figure 3: Pie chart depicting contribution of different food groups to SF intake in the UK from 2008-2009. (Food Standards Agency, 2010, pg. 9)

pathogenesis. In the *Lifestyle Heart* study, 53% of patients fed an American-diet high in SFs, sodium and cholesterol had increased atherosclerosis development than those following a WFPBD *(Tuso et al., 2015).* Major sources of cholesterol and SFs stem from the consumption of animal products such as egg yolk, organ meats, animal fats, processed meats, shellfish and full-fat dairy products. Greater consumption of animal-products correlates with a greater risk of death from CVD as supported by various studies (see figure 4) *(Kubula, 2018).* As cholesterol is only found in animal-products, those on a WFPBD are placed at lower risk of CAD *(VivaHealth, nd).*

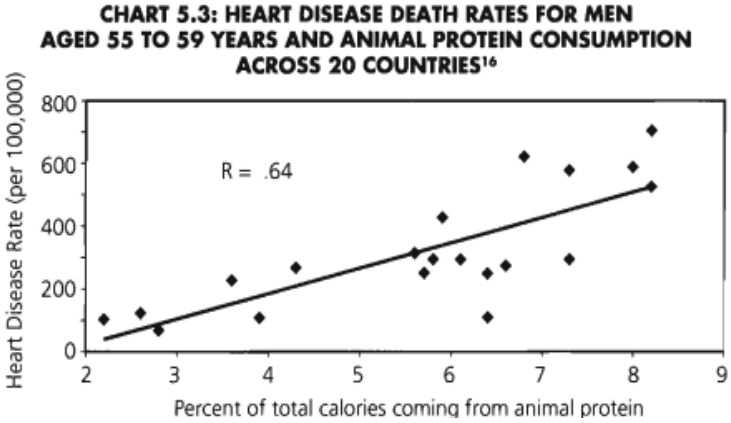

Figure 4: Correlation graph highlighting the association between percent of total calories from animal protein vs. rate of death from heart disease. (Campbell, 2006, pg. 120)

Poultry and dairy-products in the US are the leading sources of cholesterol and SFs *(What the Health, 2017).* Casein found in dairy was discovered to raise blood-cholesterol levels in an animal-model compared to soy protein *(Kuzmanov, 2016).* However, in a human-model, results presented were inconclusive. Literature published in the *American Journal of Clinical Nutrition,* where three studies of sample size greater than forty-thousand were collated, presented the finding that full-fat dairy products were not negatively-associated with CAD *(Harvard T.H. Chan, nd).* However, it was noted that replacing dairy fats with plant-based and polyunsaturated fats reduced risk of CAD by 10-24%, confirming that a WFPBD can prevent CAD *(ibid.).*

Trimethylamine N-oxide (TMAO):

Increased blood-TMAO levels have been identified as a major precursor to CAD due to its properties which allow for catalysed cholesterol and plaque build-up within the coronary arteries *(Forbes & Aitkens, 2020) (*see figure 5). TMAO has also been recognised as a marker for CAD. A study of 4007 participants published in the *New England Journal of Medicine* found that "those with elevated TMAO levels from meat consumption accounted for higher risk of CAD" (see figure 6), consequently correlating a WFPBD to lowered CAD risk (*Tuso et al., 2015).* When foods high in choline, carnitine and lecithin (red meats, eggs, dairy and seafood) are digested, the gut microbiome synthesises TMA which is converted to TMAO by the liver *(Blaak et al., 2018).* WFPBDs contain low amounts of these compounds resulting in lower risk of CAD due to lower blood-TMAO concentration. A study published in the *European Heart Journal* investigated the impact diet would have on extent of TMAO synthesis. Randomly selected participants were presented with three diets; red-meats, white-meats and non-meats. The results found that those on the red-meats diet had a blood-TMAO level three times greater than white-meats and non-meats diets *(Thøgersen et al., 2019).* "[red meat] essentially grows more microbes that can metabolise meat" *according* to Dr Manson of the HMS Division of Preventative Medicine. Those who do not consume meat on a daily basis, such as those who are plant-based, will not have adequate levels of 'meat-eating' microbes, consequently preventing synthesis of TMAO. Such individuals will continue to have low blood-TMAO levels given that they do not regularly consume meats. Increased TMAO levels have also been linked with consumption of saltwater fish and some types of cod *(Kahn, 2018).* Commonly consumed fish, however do not contain TMAO at all, thus offsetting fish consumption in the pathogenesis of CAD *(ibid.).* There have not been explicit studies investigating the correlation between fish-TMAO and CAD, however preliminary results indicate that fish has no negative correlation with CAD. Essentially, it can be recommended that a WFPBD is highly effective at preventing CAD through lowered

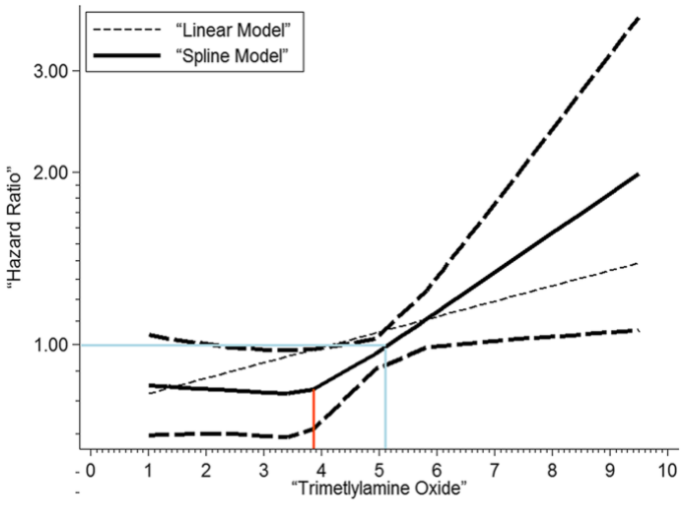

Figure 5: 95% Confidence Interval Correlation graph presenting the relationship between TMAO concentration and Hazard Ratio of CAD. (Yao, 2020, pg. 8)

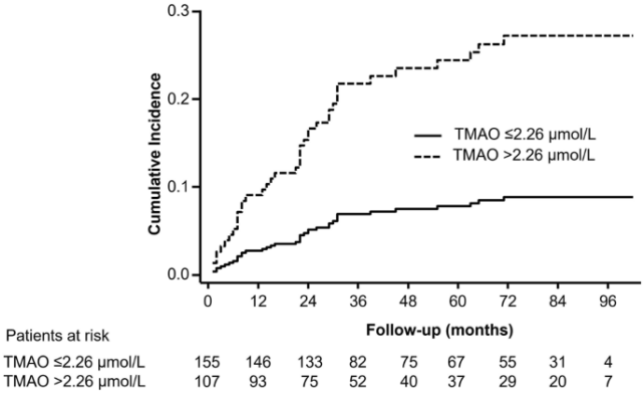

Figure 6: Cumulative Incidence Curve presenting correlation between TMAO concentration (<2.26 and >2.26) and incidence of CAD over a period of 96 months. (Roncal, 2019, pg. 5)

amounts of TMAO. However, it has been suggested that consumption of certain fish groups may have no negative-effect on CAD development and progression.

Omega-3 Fatty Acids:

Omega-3, a poly unsaturated fat that is found naturally in oily-fish has been shown to potentially decrease the risk of CVDs. Its biological properties promote the inhibition of lipid metabolism, thrombosis and inflammation, all of which are precursors of CAD *(University of Rochester Medical Centre, nd).* WFPBDs account for lower levels of omega-3 due to limited fish consumption. While multiple sources of omega-3 are available in seeds, fruits and vegetables, there are in particular two types of omega-3 found primarily in fatty-fish and scarcely in plant-based foods: DHA and EPA. These have been discovered to be protective factors of CAD *(Siscovick, 2017).* DHA and EPA have been found to lower LDL, a major contributor in the pathogenesis of CAD. They have also been found to inhibit high-levels of metalloproteinase-2, an enzyme heavily associated with plaque development. Randomised control trials correlating omega-3 and CAD presented that both dietary and supplementary sources had positive effects, however supplementary sources also showed no effects. However, supplementary sources of omega-3 utilised in this study were lower than found in consumption of fatty-fish, thus potentially resulting in the inconsistency between dietary and supplementary omega-3. Regardless, the *American Heart Association* has published that high-intakes of omega-3 can decrease hazard-ratio of CAD (refer figure 7) *(AHA, 2015).* Studies show that those on a WFPBD have a 60% lower all-omega-3 content compared to those who consumed fish regularly. They suggest that a pescatarian diet may be more beneficial in terms of preventing CAD compared to a WFPBD *(Holdford, 2017).* However, note that two major studies on the properties of omega-3 in relation to CAD are currently in progress which could potentially refute or support previous findings.

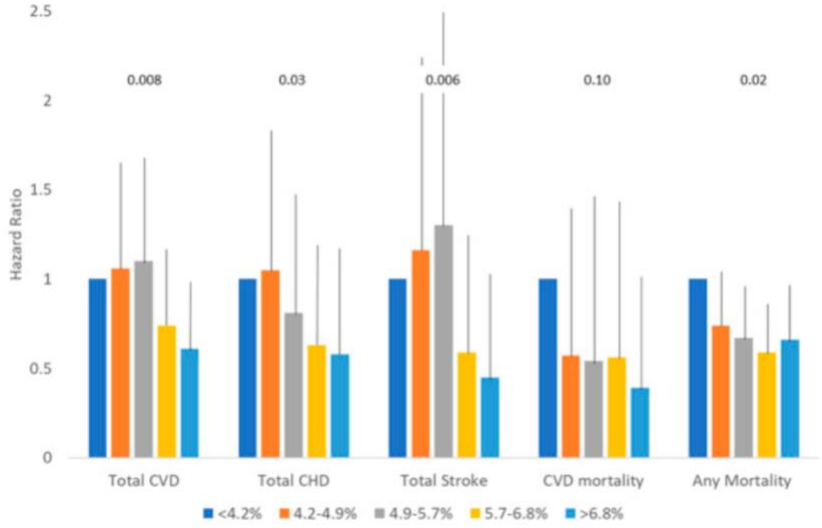

Figure 7: Relationship between Omega-3 concentration and hazard ratio of cardiovascular diseases, coronary heart disease and stroke to a 95% confidence interval. Note that CHD is the same as CAD. (Harris, 2018, pg. 7)

Association between whole-foods plant-based foods:

Reduced Cholesterol and TMAO:

As aforementioned, high cholesterol and TMAO levels identified as precursors and markers of CAD, lower-levels/elimination of these components would allow for the prevention/reversal of CAD. The dietary pattern of a WFPB-individual involves minimal consumption of animal-products - the only dietary source of cholesterol - thus those adopting a WFPBD acquire reduced blood-cholesterol levels *(Physicians Committee, nd).* Eleven similar studies showed that WFPBDs reduced not only blood-cholesterol levels but also weight and blood pressure, all three of which are mRFs of CAD *(Milks, 2019).* An independent case study experimented a WFPBD in two patients with initial cholesterol readings of 261mg/dl and 248mg/dl. Two weeks after prescribing a WFPBD, the cholesterol readings of the patients dropped to 126mg/dl and 137mg/dl, therefore reducing severity of atherosclerosis and thereby allowing for greater perfusion of the coronary arteries *(ClevelandClinic, 2014).* This can be visually represented through observing PET scans and angiograms of a patient's coronary artery before and after adopting a WFPBD (refer to figure 8 and 9).

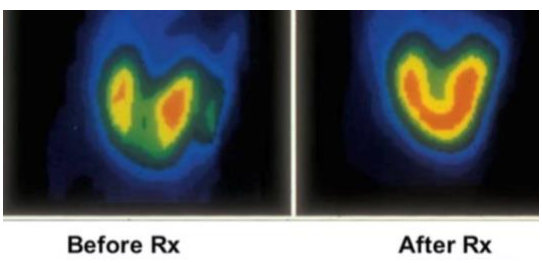

Figure 8: PET scan of a patient's coronary artery before and after prescription of a WFPBD. A coloured red area represents good perfusion and green represents poor perfusion. (ClevelandClinic, 2014)

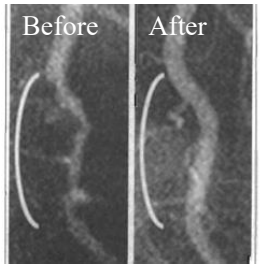

Figure 9: Angiogram of patient's coronary artery before and after adoption of a WFPBD. (Campbell, 2006)

TMAO which is synthesised from metabolites found in animal-products is not found in plant-products. A study found that participants who had switched from an animal-based diet to a WFPBD had lowered TMAO concentration (6.4μM to 2.9μM) *(Dobkowski, 2020).* A WFPBD benefits the individual in that the body is incapable of synthesising large amounts of this atherosclerotic-promoting agent, thus lowering atherosclerosis and CAD risk *(Forbes & Aitkens, 2020).* However, *Christopher Gardner, a Professor of Medicine* who has been researching health benefits of several dietary-components for twenty-years, states that "more research is needed in the area [of TMAO] for conclusive results".

Antioxidants and High Oxygen Radical Absorbance Capacity (ORAC) value:

Diets containing high amounts of antioxidants have been associated with risk-reduction of certain CVDs *(UpToDate, nd).* Good sources of antioxidants commonly derive from Vitamin C, Vitamin E, Selenium and Beta Carotene, all of which are prevalently found in fruits, vegetables and nuts *(ClevelandClinic, 2019).* For that reason, WFPBDs have been discovered to be high in antioxidants. Plaque build-up within the arteries, a major component of CAD, classified as "oxidative inflammation".

The consumption of antioxidants which are high in ORAC value has been shown to reduce plaque formation by limiting oxidation, consequently preventing lesions and CAD *(Esselstyn Jr., 2020).* Foods high in ORAC value derive only from plant-based sources with green, leafy vegetables attaining the highest *(ibid.) (Leopold, 2016).* The *Cambridge Heart Antioxidant Study* discovered that patients prescribed with supplementary antioxidants had shown a reduction in CVDs, however other contemporary studies such as the Women's Health study concluded that there was no clear link required (refer to figure 10) (ibid.). Therefore, the evidence at this stage suggests that the high-antioxidant value obtained from WFPBDs derives nil significant benefit towards CAD prevention.

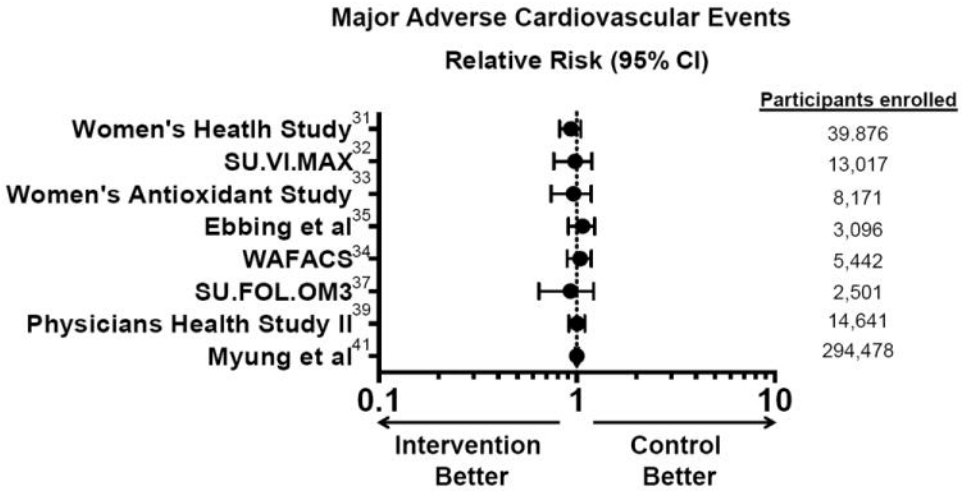

Figure 10: 95% Confidence Interval presenting a comparison of an intervention (high in antioxidants diet) and control (standard diet) in preventing CAD. (Leopold, 2016)

Conclusion:

In conclusion, evidence indicates a WFPBD prevents CAD to a moderate extent. Medical studies have presented that consumption of red-meats and poultry in particular present atherosclerotic components such as TMAO, SFs and cholesterol into the body which contribute towards the pathogenesis of CAD. As such, WFPBDs have been discovered to offer reduced concentrations of these diet-derived components. However, other studies have shown that the exclusion of fish in a WFPBD presents lower levels of omega-3, a fatty-acid known to prevent CAD. Therefore, proposing that a pescatarian-diet may offer greater preventative benefits. Additionally, where antioxidants were believed to prevent atherosclerotic diseases, multiple studies observed no clear advantage in adopting a WFPBD, naturally high in antioxidants for CAD prevention. Therefore, the application of a WFPBD may prevent CAD dependent on the extent of red-meat, poultry and fish consumption; however, it is to note that further trials are still required in order to definitively confirm this hypothesis but also that other risk factors may influence CAD.

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