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Prevalence of Health-Risk Behaviours Among Indigenous Australians With Diabetes: A Review

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Prevalence of Health-Risk Behaviours Among Indigenous Australians With Diabetes: A Review

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Abstract

Aboriginal and Torres Strait Islander Australians are at high risk of Type 2 diabetes and its complications. Optimal lifestyle choices can improve health outcomes. A thematic review of original research publications related to smoking, nutrition, alcohol intake, physical activity and emotional wellness in Aboriginal and Torres Strait Islander Australians with diabetes was performed. Overall, 7118 English-language publications were identified by search engines (PubMed, CINAHL, Scopus, Medline-Web of Science, and Google Scholar) with search terms Indigenous Australians OR Aboriginal and Torres Strait Islanders AND diabetes AND lifestyle OR smoking OR nutrition OR alcohol OR physical activity OR emotional wellbeing and their common synonyms. After review of abstracts and publication reference lists, 36 articles met inclusion criteria and were reviewed. In general, the self-reported health-related behaviours of Aboriginal and Torres Strait Islander Australian adults with diabetes, which is predominantly Type 2 diabetes, was suboptimal. An important clinical challenge in diabetes care is to sustainably reduce smoking, improve nutrition (including alcohol use), increase physical activity, reduce sedentary time, and improve emotional wellbeing, which should lead to reduced rates of diabetes complications. Regular assessments and multi-stakeholder input, including individuals, communities, clinical, health policy, societal and government inputs and partnerships, are desirable to facilitate closing the gap in health between Aboriginal and Torres Strait Islander and non-Indigenous Australians.

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Keywords

review, Indigenous Australians, diabetes, lifestyle, modifiable risk factors, smoking, nutrition, alcohol, physical activity, depression

There is a Type 2 diabetes pandemic that disproportionately affects low to middle-income countries and Indigenous peoples, including Aboriginal and Torres Strait Islander Australians (Zheng et al., 2018). Diabetes and its complications are major contributors to the health and mortality gap between Aboriginal and Torres Strait Islander Australians and non-Indigenous Australians, which, while closing, persists. Life expectancy for Aboriginal and Torres Strait Islander Australians remains eight years lower than for non-Indigenous Australians (National Indigenous Australians Agency, 2020). Aboriginal and Torres Strait Islander Australians are four times more likely to develop Type 2 diabetes, often at a younger age than non-Indigenous Australians. (Australian Institute of Health and Welfare, 2020b). Young-onset Type 2 diabetes is associated with serious health outcomes, including poorer metabolic health, chronic complications and premature death, than for people with comparable duration of Type 1 diabetes (Wong et al., 2015). This may be related to a more adverse risk factor profile in Type 2 diabetes, including obesity, dyslipidaemia and hypertension (Arslanian et al., 2018). Genetic and epigenetic factors, at the interface of genetics and environmental factors, are likely also contributory, but are to date are not often studied in Aboriginal and Torres Strait Islander Australians. (Kwak et al., 2016; Liu et al., 2015; Davegardh et al., 2018).

Lifestyle choices impact of the risk of Type 2 diabetes and its complications (Forouhi et al., 2018). A balanced diet, abstaining from smoking and risky alcohol drinking, undertaking regular physical activity, and emotional wellbeing can have positive health outcomes, including in people with diabetes (Xu et al., 2019). Achieving and maintaining a healthy lifestyle is influenced by individual, family, community, education, the healthcare system, policy, and government inputs.

Knowledge of the current and changing status of behavioural risk factors is key to planning, delivering and maintaining an environment favouring healthier lifestyle choices. This is particularly important in high-risk groups, such as Aboriginal and Torres Strait Islander Australians with Type 2 diabetes, who are more likely than non-Indigenous Australians to live outside urban areas (Burrow & Ride, 2016), which in itself is associated

with increased risk of adverse health outcomes and higher levels of socioeconomic disadvantage (Colagiuri, 2017). To assess the knowledge base, we conducted a thematic review of original research articles related to major behavioural risk factors in Aboriginal and Torres Strait Islander Australians with Type 2 diabetes. We chose the traditional risk factors related to smoking, nutrition, alcohol intake, physical inactivity, and emotional issues as they are commonly associated with cardiometabolic disease, are screened in clinical practice and are potentially modifiable (RACGP Guidelines for Diabetes Care 2020). Furthermore, as noted in our previous research (Xu D et al., 2019) these risk factors are common in Aboriginal and Torres Strait Islander Australians with diabetes.

Methods

A thematic review was performed. PubMed, CINAHL, Scopus, Medline-Web of Science, and Cinahl websites were searched for English language original research papers and references of relevant articles were searched. Search terms were "Indigenous Australians OR Aboriginal and Torres Strait Islanders" AND diabetes AND lifestyle AND smoking AND "nutrition OR diet OR food" AND alcohol AND physical activity AND "emotional wellbeing OR depression". Review articles were not included. The search start date was open, and the end date was June 17, 2022.

Results

Figure 1 shows the Consort diagram. Of 7118 abstracts identified, only eight papers met the search criteria, and review of their reference lists identified a further 28 relevant original research papers. In total, 36 publications were included in the study, only one of which gave an overview of all five Smoking, Nutrition, Alcohol, Physical activity and Emotional wellbeing (SNAPE) lifestyle behaviours (Xu et al., 2019).

Original research articles related to the main health-risk behaviours were identified and are summarised in Table 1 (Smoking), Table 2 (Nutrition and Alcohol Intake), Table 3 (Physical Activity) and Table 4 (Emotional wellbeing). The comparator group(s) for Aboriginal and Torres Strait Islander Australians with diabetes, if any, were variable, being Aboriginal

and Torres Strait Islander Australians without diabetes and/or non-Indigenous Australians with or without diabetes. Studies were predominantly cross-sectional.

Smoking Status

Smoking rates were generally high in Aboriginal and Torres Strait Islander Australians with diabetes, usually higher in men than women, and were often like rates in non-diabetic Indigenous Australians. As shown in Table 1, the majority (24) of the 36 papers identified on lifestyle risk in Aboriginal and Torres Strait Islander Australians with diabetes reported data on smoking, including 20 cross-sectional, two prospective cohort and two intervention studies. Smoking was found to be a considerable risk factor in the Davis et al., 2007; Maple-Brown et al., 2007; Davis et al., 2012; Alharbi et al., 2015; Davis et al., 2015; Cheng et al., 2019; Maple-Brown et al., 2019; and Longmore et al., 2020 studies. However, this was less clear in McCulloch et al., 2003; Simmons, 2003; Baillie et al., 2017; Chan et al., 2007; Burke et al., 2007; McDermott et al., 2015 studies.

Nutrition, Including Alcohol Consumption, Status

Suboptimal diet quality and high alcohol intake were common in Aboriginal and Torres Strait Islander Australians with diabetes, and like that of Aboriginal and Torres Strait Islander Australians without diabetes. Of nine original research papers in Table 2, three related to nutrition (McCulloch et al., 2003; Chan et al., 2007; Xu et al., 2019) and six to alcohol intake (Cheng et al., 2019; Davis et al., 2015; Davis et al., 2007; McCulloch et al., 2003; Taylor et al., 2017; Xu et al., 2019).

Dietary intake was found to be a considerable risk factor in all three nutrition studies. Alcohol consumption was found to be a considerable risk factor in the McCulloch et al., 2003; Davis et al., 2007; Davis et al., 2015; Xu et al., 2019 studies. However, this was less clear in the Cheng et al., 2019 and Taylor et al., 2017 studies.

Physical Activity Status

Five original research papers related to physical activity and/or sedentary time (Chan et al., 2007; Chung et al., 2014; Davis et al., 2007; McCulloch et al., 2003; Xu et al., 2019)

(Table 3). In these studies, association of physical activity with diabetes among Aboriginal and Torres Strait Islander Australians was uncertain.

Emotional Wellbeing Status

Seven papers related to emotional wellbeing in Aboriginal and Torres Strait Islander Australians with diabetes (Davis et al., 2015; Davis et al., 2007; Johnson et al., 2015; Schierhout et al., 2013; Si et al., 2011; Taylor et al., 2017; Xu et al., 2019) (Table 4) and generally reported sub-optimal mental health. Emotional wellbeing was found to be a considerable risk factor in the Davis et al., 2015; Johnson et al., 2015; Taylor et al., 2017 and Xu et al., 2019 studies, however, association of emotional wellbeing with diabetes among Aboriginal and Torres Strait Islander Australians was uncertain in the Davis et al., 2007; Si et al., 2011 and Schierhout et al., 2013 studies.

Discussion

Modifiable sub-optimal health-related behaviours (Daré et al., 2019) have been associated with increased risk of chronic diseases (Hackett et al., 2018), including Type 2 diabetes and its complications (Davis et al., 2015). Both diabetes and the health of Aboriginal and Torres Strait Islander Australians have long-been national health priority areas for Australia, (Australian Institutes of Health and Welfare, 1997) yet the body of original research related to major modifiable risk factors in over 24 years in Aboriginal and Torres Strait Islander Australians with diabetes is relatively small, as reflected by the small numbers of papers identified by this review. A non-time restricted search of four major electronic databases and additional searches of cited references identified only 36 publications over 24 years, with the majority (over 80%) being small, local and cross-sectional. There were two longitudinal studies, the longest being three years (Davis et al., 2012). Two studies were in rural Victoria and urban Western Australia (Davis et al., 2012; Simmons, 2003). Most studies focussed on one behaviour, with only one study, by some of the co-authors (LB, AJ), evaluating all five behavioural risk factors (Xu et al., 2019) of smoking, nutrition, alcohol, physical activity and sedentary time and emotional well-being (Xu et al., 2019). Whilst not often having all desirable comparator groups, such as Aboriginal and Torres Strait Islander

Australians without diabetes and non-Indigenous Australians with and without diabetes, these studies of Aboriginal and Torres Strait Islander Australians with diabetes provide valuable information and a foundation for future research.

Relationships Between Modifiable Risk Factors and Diabetes

Links between lifestyle and diabetes may be mediated by adverse effects of adiposity, glycaemia, blood pressure (which is influenced by salt intake) and lipids (Jenkins et al., 2019). High-density lipoprotein levels are reduced by adiposity, physical inactivity and smoking, low-density lipoprotein is increased by high-fat diets, and triglycerides rise with adiposity, hyperglycaemia and high carbohydrate diets (Rohatgi, 2017; Jenkins et al., 2019). Poor mental health in people with diabetes is associated with worse health outcomes and reduced adherence to prescribed medications (Taylor et al., 2017) and healthcare appointments (Eades & Alexander, 2019; Jenkins et al., 2019).

High Prevalence of Modifiable Risk Factors

Compared to Aboriginal and Torres Strait Islander Australians without diabetes and non-Indigenous Australians with and without diabetes, this review found that Aboriginal and Torres Strait Islander Australians with diabetes have a high prevalence of tobacco smoking, inadequate nutritional intake (Xu et al., 2019), risky alcohol consumption (Taylor et al., 2017), low physical activity levels (McCulloch et al., 2003) and poorer emotional wellbeing (McNamara et al., 2018). Being aware of a persons' health-related behaviours can help identify barriers to diabetes self-management and can help develop and sustainably implement strategies to empower and enhance self-management. Self-management is key in diabetes given that the average person with diabetes sees a healthcare professional for only several hours to days a year, yet lives with diabetes for 365 days a year (Jenkins et al., 2019). In an attempt to improve health outcomes for Aboriginal and Torres Strait Islander Australians the Australian government subsidises 10 allied health care professional appointments per year for an Aboriginal and Torres Strait Islander Australian, compared to five per year for a non-Indigenous Australian (Medicare Australia, 2020). Eligible allied health care providers include podiatrists, dietitians, diabetes educators, optometrists,

psychologists, physiotherapists and occupational therapists. We did not identify any papers reporting outcomes of this program.

Smoking

Smoking is a major risk factor for cardiovascular and respiratory disease and for chronic diabetes complications; hence non-smoking is recommended for all Australians (Department of Health, 2020). To assist people to become and remain non-smokers, there are national quit-smoking campaigns (Quitline, 2021) and local community programs (Deadly Choices, 2018). This review identified high smoking prevalence in Indigenous people with diabetes, including women, even pregnant women (Longmore et al., 2020; Maple-Brown et al., 2019). Most studies did not assess chewing (vs. smoking) tobacco nor smoking of pituri, which is not uncommon in some Aboriginal and Torres Strait Islander Australian communities (Ratsch et al., 2017). As yet there are no reports of longitudinal or intervention studies specifically targeting smoking rates in Aboriginal and Torres Strait Islander Australians with diabetes.

Recent analyses in the general Aboriginal and Torres Strait Islander population identified that although smoking rates are declining (Australian Institute of Health and Welfare, 2020a), smoking was responsible for 36.9% of all deaths (Thurber et al., 2021) and a major contributor to the life expectancy gap between Aboriginal and Torres Strait Islander Australians and non-Indigenous Australians (Closing The Gap in Partnership, 2020). A multifaceted program including individuals of all ages, communities, health policy, taxation, and prevention and behavioural and drug-based intervention programs is needed.

Nutrition

For all Australian adults, for optimal health national guidelines recommend two servings of fruit, five servings of vegetables for women and 5.5–6 servings of vegetables for men daily. Limited intake of saturated fat and refined carbohydrates and at least two servings of (preferably oily) fish per week are recommended (National Health and Medical Research Council, 2013). As summarised in Table 2, our review identified low fruit and vegetable intake and generally suboptimal diet quality in Aboriginal and Torres Strait

Islander Australians with diabetes. Remoteness may be associated with lower diet quality (Wycherley et al., 2017). Most of the reviewed nutrition studies did not assess blood levels of nutritional markers, such as folate, vitamin C and carotenoids, with good levels being associated with higher fruit and vegetable intake. Only one cross-sectional study has quantified plasma carotenoids in urban Indigenous Australians, though not specifically with diabetes, and identified positive correlations between carotenoid levels and socioeconomic status (Hodge A et al., 2011). We could not identify any such published data for longitudinal or intervention studies for nutrition in Aboriginal and Torres Strait Islander Australians with diabetes.

Alcohol

Alcohol is low in nutritional value, high in calories, and is costly. There are both acute and chronic adverse effects of excess intake, including increased risk of hypoglycaemia, hypertension, adiposity, liver damage and peripheral neuropathy. National Health and Medical Research Council (NHMRC) recommendations regarding alcohol intake are for all adult Australians, have been lowered over time (National Health and Medical Research Council, 2001, 2009, 2020). The 2009 guidelines recommended <2 standard drinks/day and <4 standard drinks on a single occasion for both sexes (National Health and Medical Research Council, 2009). The 2020 guidelines recommend ≤ 10 standard drinks/ week and four standard drinks on any one day. To prevent foetal alcohol spectrum disorder, pregnant women or women planning a pregnancy are recommended to abstain from alcohol (National Health and Medical Research Council, 2020).

Our cross-sectional study identified high rates of at-risk drinking in Aboriginal and Torres Strait Islander Australians with diabetes, with drinkers more likely to be male (49%) than female (32%), and 46% of drinkers were high-risk or likely alcohol dependent (Xu et al., 2019). Cross-sectional data from the Pregnancy and Neonatal Diabetes Outcomes in Remote Australia (PANDORA) study found that 15.5% of Aboriginal and Torres Strait Islander women with gestational diabetes vs. 10.3% of non-diabetic pregnant Aboriginal and Torres Strait Islander women consumed alcohol, but this difference did not reach statistical

significance. There were no identified longitudinal or intervention study data related to alcohol intake in Aboriginal and Torres Strait Islander Australians with diabetes.

Physical Activity

Being physically active has many health, including psychological benefits, but many Australians of all ages do not meet recommended targets. The Australian Physical Activity and Sedentary Behaviour Guidelines (2019) recommend all Australian adults, including with Type 2 diabetes, are physically active on most, and preferably all, days with a weekly total of 2.5–5 hours of moderate-intensity activity or 1.25–2.5 hours of vigorous-intensity activity (Department of Health, 2019) and 2–3 sessions of resistance training/week (Royal Australian College of General Practitioners and Diabetes Australia, 2020). Reducing sitting time is also desirable to ensure optimal health outcomes, including cardiometabolic health (Vincent et al., 2017). This review identified that many Aboriginal and Torres Strait Islander Australians with diabetes had suboptimal physical activity (Davis et al., 2007; McCulloch et al., 2003; Xu et al., 2019). Only one study (McCulloch et al., 2003) reported higher rates of adequate exercise by Aboriginal and Torres Strait Islander Australians with diabetes than non-diabetic Indigenous Australians, and another study (Chan et al., 2007) reported similar daily steps in Aboriginal and Torres Strait Islander Australians with vs. without diabetes. One study (Davis et al., 2007) reported similar exercise by Aboriginal and Torres Strait Islander Australians and non-Indigenous Australians with diabetes. Sedentary behaviour in Aboriginal and Torres Strait Islander Australians with diabetes was only reported in one paper (Xu et al., 2019). While some longitudinal or intervention studies were identified, the reported data for Aboriginal and Torres Strait Islander Australians with diabetes was cross-sectional baseline data only.

Emotional Wellbeing

Mental health cannot be separated from physical health. There are recognised bidirectional links between mental wellbeing and physical health, including in people with diabetes (Alzoubi et al., 2018). Suboptimal mental health can lead to lifestyle choices such as poor nutrition, lack of exercise, obesity and smoking, which are risk factors for Type 2

diabetes and its chronic complications (Mulligan et al., 2018). Diabetes, even without chronic complications, is associated with increased risk of mental health problems such as anxiety, depression and "diabetes distress" (Gubhaju et al., 2013) and burn-out. Diabetes distress is characterised by features such as anger, frustration, worry about diabetes, lack of motivation (Kreider, 2019), and making unhealthy food choices (Heinze et al., 2019). Poor mental health has been associated with worse metabolic control of diabetes and higher rates of chronic complications and adverse outcomes (Robinson et al., 2018). Recognition, support from family, friends and healthcare professionals and treatment such as cognitive behaviour therapy and sometimes medication can be used to treat diabetes distress (Kalra et al., 2018), which is often episodic and recurrent.

While there may be cultural and individual barriers for Aboriginal and Torres Strait Islander Australians discussing mental wellbeing, our review identified seven publications in which suboptimal mental health for Aboriginal and Torres Strait Islander Australians with diabetes was not uncommon, as was also so in any comparator groups of non-Indigenous Australians with diabetes. There were no identified data from longitudinal or intervention studies of mental wellbeing in Aboriginal and Torres Strait Islander Australians with diabetes. One intervention study, albeit not in Aboriginal and Torres Strait Islander Australians with diabetes, has demonstrated positive effects of dietary modification on depressive symptoms. The SMILES study was a 12-week randomised control trial of a Mediterranean dietary intervention combined with nutritional counselling that proved effective in the management of severe depression in Australian adults (Opie et al., 2018). Studies evaluating nutrition and mental health in Aboriginal and Torres Strait Islander Australians with diabetes would be of value.

Study Strengths and Limitations

Strengths of this review relate to the common and clinically important health problem of diabetes in Aboriginal and Torres Strait Islander Australians and its focus on potentially modifiable behavioural risk factors. No time restriction on relevant publications was placed, so the search spanned 25 years, up to mid-June 2022.

Study limitations are that the review was thematic, not systematic and that a meta-analysis was not performed. The relatively small number of studies and small study size, different study design types, and wide variation in reported detail and comparator groups precluded a meta-analysis. The search was restricted to English only, but it is unlikely that there are many non-English publications. Most Aboriginal and Torres Strait Islander Australian diabetes studies are of Type 2 diabetes, with Type 1 diabetes and other genetic and secondary forms of diabetes being far less common in Aboriginal and Torres Strait Islander Australians. Only one study related to gestational diabetes, which affects 78% of pregnant Aboriginal and Torres Strait Islander women, was identified (Maple-Brown et al., 2019).

It is recognised that most identified studies are based on self-report and that validation measures, such as nutrition markers or physical activity monitors, are costly and were not included in most studies. There may be selection bias in study participation, and there may also be publication bias. Few studies were national studies, and it is recognised that findings in one site may not be generalisable. The reported studies spanned over two decades, and risk factor levels may have changed since publication.

Future Directions

Further cross-sectional and longitudinal studies of lifestyle and modifiable risk factors in Aboriginal and Torres Strait Islander Australians with and without diabetes and with non-Indigenous Australian comparator groups are desirable. Detailed participant characterisation with biochemical measures and, where relevant and approved by participants, genetic and epigenetic factors are also desirable. To improve modifiable risk factors in Aboriginal and Torres Strait Islander Australians (with and without diabetes), culturally appropriate education and intervention programs codesigned and ideally conducted by Aboriginal and Torres Strait Islander Australians are desirable. There must be adequate resources to develop, implement and sustain effective programs in urban, regional, rural, remote, and very remote regions.

Conclusions

Modifiable health-related behaviours contribute to health outcomes, and diabetes and the health gap between Aboriginal and Torres Strait Islander Australians and non-Indigenous Australians are national health priorities. Despite this, there is a valued small body of original research, and most studies are small, cross-sectional and not nationwide. Overall, Aboriginal and Torres Strait Islander Australians had inadequate outcomes across each of the evaluated modifiable health-related behaviours. More work needs to be done to evaluate and address modifiable risk factors in Aboriginal and Torres Strait Islander Australians with or at risk of diabetes, including diabetes in pregnancy. A collaborative, multifaceted approach with many diverse stakeholders is desirable. Embedding assessments of modifiable lifestyle-related risk factors into routine healthcare, and utilising electronic medical records may assist this important endeavour.

Declarations

Ethics Approval and Consent to Participate

The study was approved by the University of Melbourne Human Research Ethics Committee (ID: 17505904), and the trial registered with the Australian and New Zealand Clinical Trials Registry (ACTRN12618001204235). The study site's governance board and executive management, which included Indigenous Australian community representatives, approved the iDEES study.

Consent for Publication

Written consent was provided by participants.

Availability of Data and Materials

This is not applicable as no original data was reported.

Competing Interests

The authors declare there are no competing interests.

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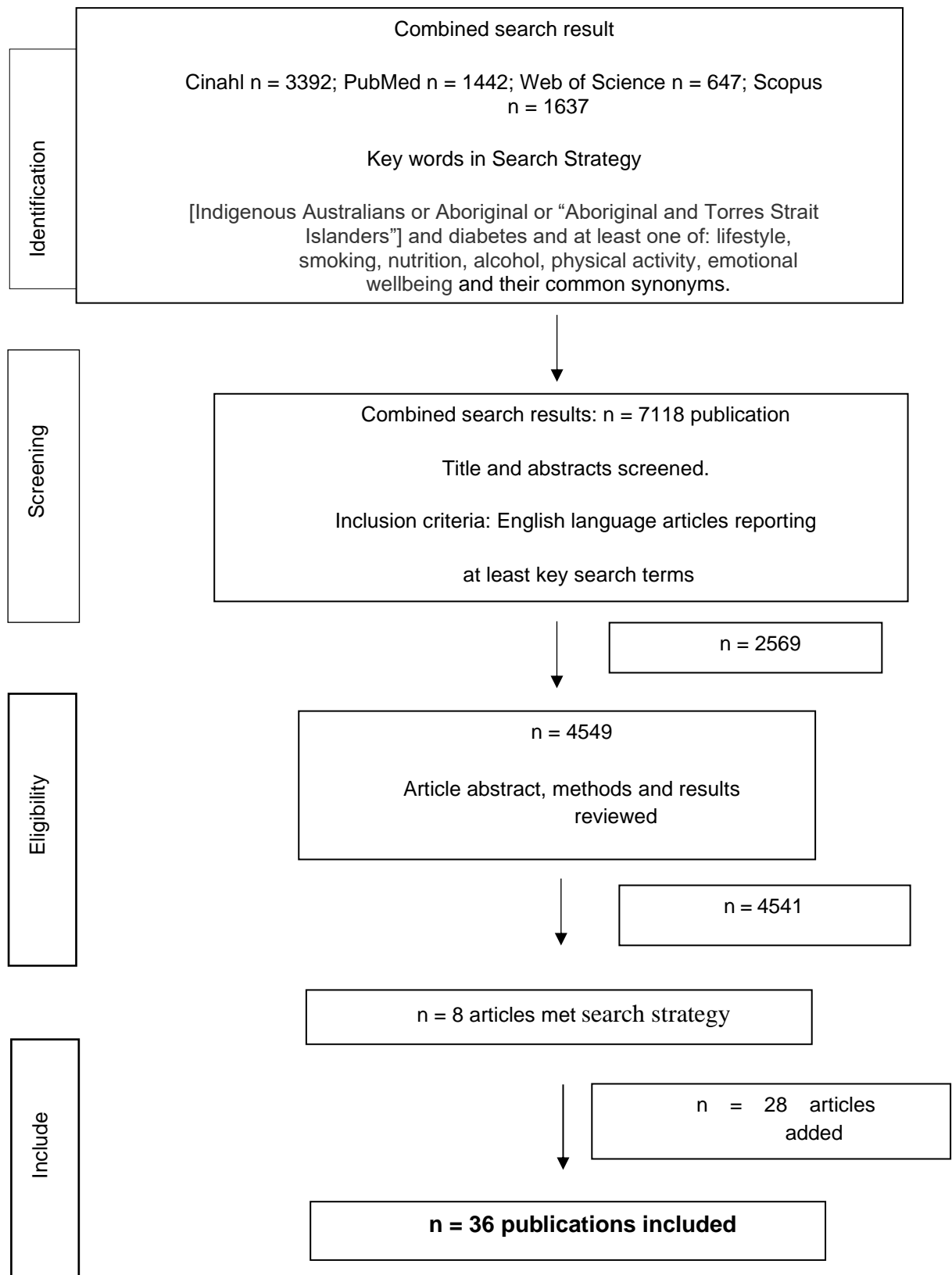


Figure 1
Consort diagram of identification of original research papers related to major modifiable risk factors in Aboriginal and Torres Strait Islander Australians with diabetes for review

Table 1

Summary of original research articles related to smoking by Aboriginal and Torres Strait Islander Australians with diabetes

First author [Reference no.]	Study setting	Prevalence or description of SNAPE* behaviour among Aboriginal and Torres Strait Islander Australians with diabetes	Number in study	Study design	Study type
Smoking					
McCulloch <i>et al.</i> 2003(McCulloch <i>et al.</i> , 2003)	Remote northern QLD	CS: 40% IAD vs. 63% IA; $p < 0.001$	2,862 IA, including 362 IAD	Assessment of self-reported diabetes and health behaviours in remote Indigenous communities in Northern Queensland. (1998-2000). Final visit smoking data vs. baseline visit data in those who seen more than once during the audit period (1999 – 2001)	C
Simmons. 2003(Simmons, 2003)	Rural VIC	CS: 30% baseline and at final visit during audit period i.e. no change	30 IAD	Health centre intervention in 7 services over 3 years of 3-monthly visits based on clinical guidelines	L
Baillie <i>et al.</i> 2004(Baillie <i>et al.</i> , 2017)	Remote NT	CS: 31% at baseline vs. 24% at 3-yr visit; $p = 0.06$	137 IAD	Audit from diabetes registers in 21 primary healthcare centres (2002–2003)	I
McDermott <i>et al.</i> 2004(McDermott <i>et al.</i> , 2004)	Remote QLD, NT	CS: 33% NT, 29% Cape York QLD, 25% Torres Strait QLD.	1,367 AD, including (IAD/AD) Torres Strait (909/921), Cape York (250/252), NT (186/194)	Cardiovascular risk factors compared in IAD and IA without diabetes.	C
Chan <i>et al.</i> 2005(Chan <i>et al.</i> , 2005)	QLD	CS: 44% without diabetes vs. 28% with diabetes	119 IA [53 IAD 66 IA without diabetes]	2-year CVD risk factor intervention - The healthy lifestyle program (HELP). Only baseline smoking data reported.	C
Chan <i>et al.</i> 2007(Chan <i>et al.</i> , 2007)	Urban QLD	CS baseline: 26% IAD vs. 43% IA without diabetes ($p = 0.17$)	101 IA [44 IAD 57 IA no diabetes]	Health-related behaviours as predictors of mortality and morbidity in IA with and without diabetes. Age range 15-88	C
Burke <i>et al.</i> 2007(Burke <i>et al.</i> , 2007)	WA	CS baseline: IAD [35% men and 32% women] vs. IA without diabetes [57% men and 26% of women]	256 IA men 258 IA women, including 45 IAD men and 59 IAD women		C

Davis <i>et al.</i> 2007 (Davis et al., 2007)	Urban WA	CS baseline: 44% IAD vs. 15% non-IA with diabetes; $p = 0.003$	837 with diabetes [18 IA and 819 NIA]	Characteristics and outcomes of T2D in urban Aboriginal people: the Fremantle Diabetes Study	C
Maple-Brown <i>et al.</i> 2007 (Maple-Brown et al., 2007)	NT	CS <u>with diabetes</u> : 9% ($n = 3$) urban non-IA vs. 31% ($n = 20$) urban IAD and 41% ($n = 12$) remote IAD; $p < 0.005$. CS <u>without diabetes</u> : 9% ($n=8$) urban non-IA vs. 49% ($n=39$) urban IA and 57% ($n=51$) remote IAD; $p < 0.005$	385 (263 IA [169 without diabetes, 94 IAD] and 122 NIA [87 without diabetes, 35 NIAD])	Impact of diabetes and components of the metabolic syndrome in Aboriginal and Torres Strait Islander Australians in remote and urban settings. Indigenous Australians with diabetes	C
Thomas <i>et al.</i> 2007(Thomas et al., 2007)	National	CS: 38% IAD vs. 9% non-IA with diabetes; $p < 0.001$	144 IAD, 449 NIAD	The National Evaluation of the Frequency of Renal Impairment co-existing with NIDDM (NEFRON) study ($n = 3,893$) – comparator group consecutively recruited at same clinics and by same doctor as IAD	C
Haswell-Elkins <i>et al.</i> 2008(Haswell-Elkins et al., 2008)	Torres Strait QLD	CS: 44% IAD vs. 42% IA without diabetes	182 IA [43 IAD, 139 IA without diabetes]	Association between urinary cadmium level and albuminuria	C
Maple-Brown <i>et al.</i> 2008(Maple-Brown et al., 2008)	Urban NT	CS: 26% known diabetes vs.64% newly diagnosed; $p < 0.0005$	135 IAD [know-diabetes 99, newly-diagnosed 36]	Assessment of management and complications of T2D in urban Aboriginal and Torres Strait Islander Australians in the DRUID study.	C
Davis <i>et al.</i> 2012(Davis et al., 2012)	Urban WA	CS [Phase 1]: 42% IAD vs.15% non-IA with diabetes; $p = 0.009$ CS [Phase 2]: 44% IAD vs. 8% non-IA with diabetes; $p < 0.001$; Disparities persist.	125 IAD, 796 NIAD	Assess disparities in risk factors and complications between IAD and non-IA with T2D. Phase 1 1993-1996, Phase 2 2008-2011.	L
Schierhout <i>et al.</i> 2013 (Schierhout et al., 2013)	NT, WA, NSW, QLD	CS: 35%	1174 IAD	Assess influence of competing demands in diabetes care on depression outcomes in 44 Indigenous clinics	C
Chung <i>et al.</i> 2014 (Chung et al., 2014)	Urban ACT	CS:29%	65 AD [85% IAD]	Assess diabetes management in sample of active clinical population	C
Alharbi <i>et al.</i> 2015 (Alharbi et al., 2015)	NSW	Ever-smoker status: 65% IAD vs. 44% Anglo-Celtic; $p < 0.0001$. IAD highest ever-smoker prevalence compared to other ethnic groups.	8,484 [345 IAD]	Ethnic-specific differences at last visit in an established Australian multi-ethnic cohort, also including Mediterranean, Chinese, Arabic, Indian, Pacific Islanders.	C

Davis <i>et al.</i> 2015 (Davis <i>et al.</i> , 2015)	Urban WA	CS: 45% IAD vs. 8% NIAD; $p < 0.001$	107 IAD, 793 NIAD	Fremantle Diabetes Study Phase 2: Prevalence and associates of depression	C
Johnson <i>et al.</i> 2015 (Johnson <i>et al.</i> , 2015)	Nth QLD	CS: 46% Aboriginal vs. 35% TSI; $p = 0.13$	193 IAD [96 Aboriginal, 97 TSI]	Characteristics of Aboriginal and Torres Strait Islander Australian adults (aged 18 – 65 years) with poorly controlled diabetes in 12 primary healthcare.	C
McDermott <i>et al.</i> 2015 (McDermott <i>et al.</i> , 2015)	Remote QLD	CS: Controls - 38% baseline vs. 31% endpoint; Intervention group – 40% baseline vs. 42% intervention group; p non-significant	213 IAD [100 intervention, 113 control]	Evaluation of community-based health-worker led approach to improve diabetes care in 12 remote Indigenous communities	I
Taylor <i>et al.</i> 2017 (Taylor <i>et al.</i> , 2017)	Torres Strait Islands	CS by depression status: 37% non-minimal vs. 51% mild vs. 11% moderate-severe; $p = 0.784$	188 IAD	Depression and diabetes	C
Cheng <i>et al.</i> 2019 (Cheng <i>et al.</i> , 2019)	NT	Antenatal smoker: 51% IA with GD vs. 39% IA without GD; $p = 0.17$ 14% NIA with GD vs. 17% NIA without GD; $p = 0.56$	Pregnant with GD [97 IA, 113 NIA] And Pregnant controls [235]	PANDORA study	C
Maple-Brown <i>et al.</i> 2019 (Maple-Brown <i>et al.</i> , 2019)	NT	Smoking in pregnancy: T2D - 39% IAD vs. 4% NIAD; $p = 0.003$; GD - 45% IAD vs. 11% NIAD; $p < 0.001$:	900 pregnant women [425 IAD, 475 NIAD]	PANDORA study	C
Xu <i>et al.</i> 2019 (Xu <i>et al.</i> , 2019)	NT	CS: 50% men, 23% women; $p < 0.001$	210 IAD	Telehealth Eye and Associated Medical Services Network project.	C
Longmore <i>et al.</i> 2020 (Longmore <i>et al.</i> , 2020)	NT	Smoking in pregnancy: 43% IAD vs. 15% NIAD; $p < 0.001$	272 IAD, 208 NIAD	PANDORA study of pregnant women	C

Abbreviations: CS current smoker; C cross-sectional; L longitudinal; I intervention; IA Aboriginal and Torres Strait Islander Australian; NIA non-Indigenous Australian; IAD Aboriginal and Torres Strait Islander Australian with diabetes; NIAD non-Indigenous Australian with diabetes; GD gestational diabetes; T2D Type 2 diabetes

Table 2

Summary of original research articles related to nutrition and to alcohol intake by Indigenous Australians with diabetes

First author [Reference no.]	Setting	Prevalence or description of SNAPE* behaviour among Aboriginal and Torres Strait Islander Australians with diabetes	Number in study	Study title or summary	Study type
Nutrition					
McCulloch <i>et al.</i> 2003 (McCulloch <i>et al.</i> , 2003)	QLD	Adequate fruit intake (≥ 2 servings fruit): 32% IAD vs. 25% IA no diabetes; adjusted $p = 0.128$	2862 IA, 362 IAD	Assessment of self-reported diabetes and health behaviours in remote Indigenous communities in Northern Queensland. (1998-2000).	C
Chan <i>et al.</i> 2007 (Chan <i>et al.</i> , 2005)	QLD	No difference in diet quality score: 16.3 IAD vs. 16.0 IA without diabetes; $p = 0.70$	44 IAD, 57 IA without diabetes	Cardiovascular health intervention program- The health lifestyle program (HELP) for Aboriginal and Torres Strait Islander Australians with and without T2D. The healthy lifestyle programme (HELP) for Indigenous Australian with diabetes (n=101).	C
Xu <i>et al.</i> 2019 (Xu <i>et al.</i> , 2019)	NT	None of the study participants reported an adequate vegetable intake. Only 9.6% reported an adequate fruit intake.	210 IAD	Health-related behaviours in a remote Indigenous population with T2D: a Central Australian primary care survey in the Telehealth Eye and Associated Medical Services Network project.	C
Alcohol					
McCulloch <i>et al.</i> 2003 (McCulloch <i>et al.</i> , 2003)	Nth QLD	Alcohol consumers: 16% IAD vs. 6% IA without diabetes; High-risk drinkers: 4% in both groups; IAD were as likely to drink at hazardous or harmful levels.	2862 IA, 362IAD	Assessment of self-reported diabetes and health behaviours in remote Indigenous communities in Northern Queensland. (1998-2000).	C
Davis <i>et al.</i> 2007 (Davis <i>et al.</i> , 2007)	Urban WA	Heavy drinkers (>3 standard drinks/day): 22% IAD vs. 7% NIAD, $p = 0.039$	18 IAD 819 NIAD	Characteristics and outcomes of T2D in urban Aboriginal people: the Fremantle diabetes study.	C
Davis <i>et al.</i> 2015 (Davis <i>et al.</i> , 2015)	WA	No difference in prevalence of alcohol consumption between IAD and NIAD Risky drinking [≥ 3 standard drinks daily]: 22% IAD vs. 7% NIAD, $p = 0.039$	107 IAD, 793 NIAD	Fremantle Diabetes Study Phase 2. Prevalence and associates of depression in Aboriginal and non-Aboriginal Australians with T2D	C
Cheng <i>et al.</i> 2019 (Cheng <i>et al.</i> , 2019)	QLD	15.5% IA with GD vs. 10.3% IA without GD, $p = 0.23$	GD [97 IA, 113 NIA] No GD controls [235]	PANDORA study of pregnancy comparing women with gestational diabetes managed by lifestyle modification alone and controls without hyperglycaemia	C

Taylor <i>et al.</i> 2017(Taylor et al., 2017)	Torres Strait Islands	Score in alcohol consumers vs. abstainers, p = 0.784; High risk alcohol consumption (>2 standard drinks/day): 37% in non-minimal depression group vs. 54% mild vs. 9% moderate-severe, p = 0.842	188 IAD	Depression and diabetes in the remote Torres Strait Islands. Participants.	C
Xu <i>et al.</i> 2019 (Xu et al., 2019)	NT	Alcohol consumers: 49% men vs. 32% women, p = 0.008; Among drinkers, 8% were at-risk, 36% were high-risk and 10% likely-dependant, p value non-significant	210 IAD	Health-related behaviours in a remote Indigenous population with Type 2 diabetes: a Central Australian primary care survey in the Telehealth Eye and Associated Medical Services Network [TEAMSnet] project.	C

Table 3

Summary of original research articles related to physical activity by Aboriginal and Torres Strait Islander Australians with diabetes

First author [Reference no.]	Setting	Prevalence or description of SNAPE* behaviour among Aboriginal and Torres Strait Islander Australians with diabetes	Number in study	Study title or summary	Study type
Physical Activity					
McCulloch <i>et al.</i> 2003(McCulloch et al., 2003)	Nth QLD	Participation in adequate exercise (30 min 3 days a week:) 58% IAD vs. 51% IA without diabetes, p = 0.018	2,862 IA, including 362 IAD	Assessment of self-reported diabetes and health behaviours in remote Indigenous communities (1998- 2000)	C
Chan <i>et al.</i> 2007(Chan et al., 2007)	QLD	Daily steps similar: 6148 IAD vs. 7163 IA non- diabetes, p = 0.39	44 IAD, 57 IA without diabetes	Cardiovascular health intervention program- The health lifestyle program (HELP) for Aboriginal and Torres Strait Islander Australians with and without T2D.	C
Davis <i>et al.</i> 2007(Davis et al., 2007)	WA	Participation in some exercise in past 2-weeks similar: 61% IAD vs. 72% NIAD, p = 0.30	837 diabetes [18 IA and 819 NIAD]	Characteristics and outcomes of T2D in urban Aboriginal people: the Fremantle Diabetes Study	C
Chung <i>et al.</i> 2014(Chung et al., 2014)	ACT	Exercise [>30 min/day]: 35% attended diabetes clinic vs 60% didn't attend, no p value given	51 IAD	Assess diabetes management in sample of active clinical population. Exercise status by attendance at diabetes clinic.	C
Xu <i>et al.</i> 2019(Xu et al., 2019)	NT	IAD walked ≥10 minutes at a time on 6-days/week and spent 4.8 hours sitting on a weekday.	210 IAD	Health-related behaviours in a remote Indigenous population with T2D: a Central Australian primary care survey in the Telehealth Eye and Associated Medical Services Network [TEAMSnet] project. Findings from the SNAPE physical activity and sedentary survey	C

Abbreviations: C cross-sectional; L longitudinal; I intervention; IA Aboriginal and Torres Strait Islander Australian; NIA non-Indigenous Australian; IAD Aboriginal and Torres Strait Islander Australian with diabetes; NIAD non-Indigenous Australian with diabetes; T2D Type 2 diabetes.

Table 4

Summary of original research articles related to emotional wellbeing by Aboriginal and Torres Strait Islander Australians with diabetes

First author [Reference no.]	Setting	Prevalence or description of SNAPE* behaviour among Aboriginal and Torres Strait Islander Australians with diabetes	Number in study	Study title or summary	Study type
Emotional wellbeing					
Davis <i>et al.</i> 2007(Davis et al., 2007)	WA	Depression: 41% IAD vs. 30% NIAD; p = 0.42	837 with diabetes [18 IA and 819 NIA]	Characteristics and outcomes of T2D in urban Aboriginal people: the Fremantle Diabetes Study	C
Si <i>et al.</i> 2011 (Si et al., 2011)	NSW,NT, QLD,WA	Overall, 8.8% had documented depression; By service: 14 documented 0%; 48 documented 3%-37% No sub-analyses by ethnicity	1592 diabetes [1405 IAD 187 NIAD]	Documented depression in patients with diabetes across 62 Indigenous community healthcare services, with 88% being Indigenous.	C
Schierhout <i>et al.</i> 2013(Schierhout et al., 2013)	NT, QLD	6% documented depression; 5% another mental health condition.	1174 IAD	Impact of competing demands in diabetes care on depression outcomes in 44 Indigenous clinics	C
Davis <i>et al.</i> 2015(Davis et al., 2015)	WA	Depression: 25% IAD vs. 11%, NIAD p=0.16; Major depression: 15% IAD vs. 4% NIAD, p=0.03; Untreated depression: 69% IAD vs. 30% NIAD, p=0.032	107 IAD, 793 NIAD	Fremantle Diabetes Study Phase 2. Prevalence and associates of depression in Aboriginal and non-Aboriginal Australians with T2D	C
Johnson <i>et al.</i> 2015(Johnson et al., 2015)	QLD	Anxiety/depression: 63%; Moderate depression: 8%	193 IAD	Characteristics of Indigenous adults (aged 18 – 65 years) with poorly controlled diabetes in 12 primary healthcare clinics.	C
Taylor <i>et al.</i> 2017(Taylor et al., 2017)	Torres Strait	PHQ-9 score s 5.5 Depression: 42% none-minimal, 46% mild, 12% moderate-severe	188 IAD	Depression and diabetes in the remote Torres Strait Islands. Participants.	C
Xu <i>et al.</i> 2019(Xu et al., 2019)	N	Adapted Patient Health Questionnaire 9 score 4.61; 34% mild depressive symptoms, 11% moderate-severe depressive symptoms.	210 IAD	Health-related behaviours in a remote Indigenous population with T2D: a Telehealth Eye and Associated Medical Services Network [TEAMSnet] project.	C