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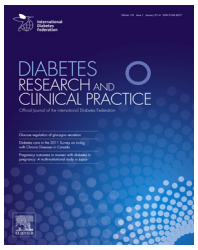

Review

A profile of diabetes in Pacific Island Countries and Territories

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ABSTRACT

Aim: To examine the available evidence about the epidemiology, health, social, and economic impact of diabetes in Pacific Island Countries and Territories (PICTs).
Methods: We conducted a systematic review of the peer-reviewed literature published in English from January 1990 to January 2014, and relevant technical reports.
Results: A total of 1548 articles were identified of which 35 studies of type 2 diabetes met the inclusion criteria. Eighteen technical reports were also included. We found no articles reporting on type 1 diabetes or gestational diabetes that met the inclusion criteria. The prevalence, risk factors and complications of diabetes were substantial. Diabetes prevalence rate of around 40% was common. Physical inactivity, overweight and obesity were leading risk factors. High rates of diabetes complications were reported e.g. up to 69% retinopathy. Poor clinical outcomes were also reported with over 70% not meeting glycaemic control targets and approximately 50% not meeting blood pressure and cholesterol targets.
Conclusion: This review highlights the burden of diabetes in PICTs and the need for more intensive interventions to improve the quality and outcomes of diabetes care. Overall, further research is needed to monitor secular diabetes trends in PICTs using standardised criteria for diagnosing diabetes and its complications.

Contents

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1. Introduction

It is well recognised that the increasing health crisis in diabetes continues to impact on human and economic development globally. Some 382 million people worldwide have diabetes and the Western Pacific Region constitutes 36% of the total number of people with diabetes [1,2]. Of particular concern is the increasing prevalence of diabetes in Pacific Island Countries and Territories (PICTs) where seven out of top ten countries with the highest diabetes rates in the world are found [1,2]. PICTs also suffer a high prevalence of debilitating diabetes complications [3].

These small developing island states are poorly equipped to face the human and economic development challenges arising from the consequences of diabetes [4,5]. To address these challenges more effectively and strategically, a comprehensive understanding of the epidemiology, health, social, and economic impacts of diabetes is required. While diabetes in some regions has been reviewed [6–11], there has been no recent review specifically focusing on PICTs.

2. Methods

We conducted a systematic review of the peer-reviewed literature on type 1 diabetes, type 2 diabetes and gestational diabetes in PICTs that was published in English from January 1990 to January 2014.

Medline, Pre-Medline and Embase databases were searched using the key terms ''diabetes mellitus'', ''type 1 diabetes'', ''type 2 diabetes'', ''gestational diabetes'', and ''Pacific Islands''. We also searched with specific terms (incidence, prevalence, risk factors, complications, mortality, quality of care, quality of life and health care costs), individual country (22 PICTs including American Samoa, Cook Islands, Fiji, French Polynesia, Guam, Kiribati, New Caledonia, Niue, Commonwealth of the Northern Mariana Islands (CNMI), Palau, Papua New Guinea (PNG), Pitcairn Islands, Samoa, Solomon Islands, Tokelau, Tonga, Marshall Islands, Federated States of Micronesia (FSM), Nauru, Tuvalu, Vanuatu, and Wallis and Futuna), and subregions in the Pacific (Micronesia, Polynesia and Melanesia).

To augment the peer-reviewed literature, we reviewed related technical reports from authoritative sources. These were accessed by searching websites of the World Health Organisation (WHO) and PICT's Ministries of Health.

Studies and technical reports were included if they reported on diabetes prevalence and/or incidence, risk factors for diabetes, diabetes-related microvascular and/or macrovascular complications, diabetes-related mortality, diabetes care, quality of life and the financial cost of diabetes. Journal articles and technical reports were excluded if they did not meet the inclusion criteria, reported on any uncommon forms of diabetes or focused on experimental intervention trials.

Two authors independently screened the titles and abstracts of each article to identify potentially eligible articles in the review. Any uncertainty or ambiguity was resolved through discussion with a third author. Full-texts of eligible articles were retrieved for detailed assessment. The research team reviewed and summarised the included articles and technical reports. The summaries were then collated and the findings are presented within each category of interest.

3. Results

A total of 1548 articles were identified through the database searches (Fig. 1). After duplicates were removed, 1273 articles remained of which 69 full-text articles were selected and assessed for eligibility. A total of 35 articles (28 cross sectional, two longitudinal and five cohort studies) from 13 PICTs (CNMI, FSM, Fiji, Guam, Kiribati, Marshall Islands, Nauru, New Caledonia, PNG, Samoa, Solomon Islands, Tonga and Vanuatu) were eligible for inclusion. All included articles reported on type 2 diabetes. We found no articles reporting on type 1 diabetes or gestational diabetes that met the inclusion criteria.

Additionally, we included 18 technical reports identified through relevant websites. They were WHO global status report on non-communicable diseases 2011 [12], report on non-communicable diseases in the Western Pacific Region 2012 [13], report on risk factors for chronic non-communicable diseases in Wallis and Futuna [14], and 15 WHO STEPwise chronic disease risk factors surveillance country reports [15]. In total, 35 peer reviewed articles identified through database

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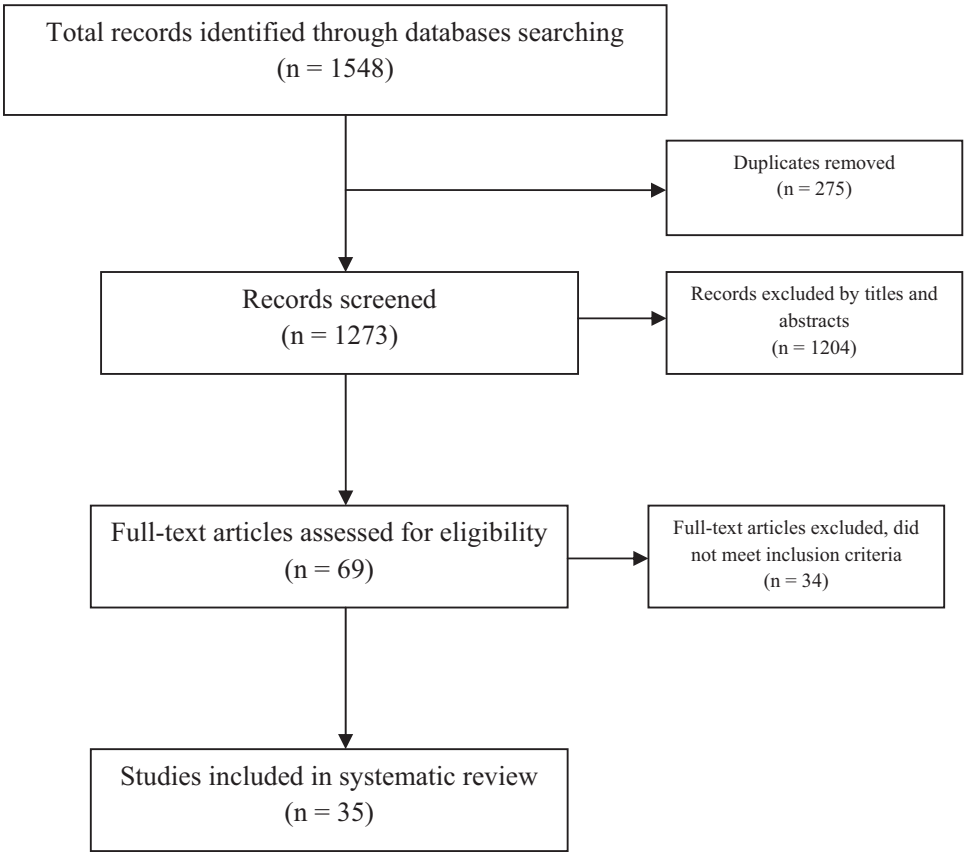

Fig. 1 – Flow chart of databases search yield and study selection for systematic review.

searches and 18 technical reports identified through WHO and PICT government websites were included in this review.

3.1. *Prevalence and incidence*

Table 1 shows the prevalence of diabetes in PICTs reported in the peer-reviewed literature. This comprised 16 cross sectional prevalence studies from 10 PICTs. The methodologies and diagnostic criteria used in the studies varied. Of the 16 studies, seven used the 1985 WHO definition of diabetes i.e. (FPG $\geq$ 7.8 mmol/l and/or 2-h post challenge glucose (2-h PG) $\geq$ 11.1 mmol/l). Diabetes prevalence varied widely across the available studies. High diabetes rates were reported in Nauruans aged >40 years (49.0%) [16], the Wanigela people of PNG aged $\geq$25 years (48.7%) [17], and Fijians aged $\geq$40 years (44.8%) [18]. Low rates (of approximately 1%) were reported in some Melanesian countries such as PNG (1.8% in Gomog community, 0.7% in Marup community and 0.6% in Kaul community; aged $\geq$ 20 years) [19], rural Fiji (1.2% male and 0.9% female aged $\geq$ 40 years in Viti Levu community) [20] and rural Vanuatu (1.0% male and 0.9% female aged $\geq$ 20 years in Tanna community) [21,22]. The prevalence of diabetes was significantly higher in urban dwellers than their rural counterparts in most PICTs [20,22–24]. For example, the prevalence of diabetes in urban Fiji was 2.8% male and 11.3% female whereas in rural Fiji it was 1.2% male and 0.9% female ($P < 0.005$) [20]. The prevalence of diabetes was also significantly higher in Polynesians (15.5%) than Melanesians or Europeans (8.4%) ($P < 0.05$) [25].

Table 2 shows the prevalence of diabetes as reported in WHO STEPS survey country reports. The prevalence was substantial and increased with age. The highest prevalence was found in American Samoa 47.3% (aged 25–64 years) and the lowest in the Solomon Islands 13.5% (aged 25–64 years) [15].

The prevalence data reported in WHO STEPS surveys were generally more recent than those reported in the peer-reviewed literature. There was wide variation between WHO STEPS survey reports and the peer-reviewed articles in parameters such as: the year the studies were undertaken, the age of the study population, and the diagnostic methods used. However, overall, there was an upward trend in diabetes prevalence. One Samoan study specifically reported on prevalence trends over time. It found that between 1978 and 1991, the age standardised prevalence of type 2 diabetes increased from 8.1 to 9.5% and 8.2 to 13.4% in men and women respectively in the Apia community; from 0.1 to 5.3% and 5.4 to 5.6% in men and women respectively in the Poutasi community; and from 2.3 to 7% and 4.4 to 7.5% in men and women respectively in the Tuasivi community [23].

Only one report on incidence was identified. This peer-reviewed article reported a diabetes incidence of 62.8 (per 1000 person-years) in Nauruans aged 12–75 years [26].

Table 1 – Diabetes prevalence in PICTs.

Author	Year of survey	Country (sample site)	Study design	Response rate (%)	Sample size (*n*)	Age (years)	Female % or *n*	Diagnosis method	Diagnosis criteria	Diabetes prevalence %	IFG and/or IGT prevalence %	Age adjusted
Benjamin [63]	1995–1999	PNG (National Capital District)	CS	NR	769	≥12	49.9%	FCBG	FCBG ≥ 7.0 mmol/l	13%	NR	No
Brian et al. [18]	2009	Fiji (Viti Levu Island)	CS – cluster sampling	NR	1353	≥40	NR	HbA1c	HBA1c ≥ 6.5% or known diabetes	44.8%	NR	Yes
Colagiuri et al. [27]	1998–2000	Tonga (Tongatapu, Vava'u and Haapai Islands)	CS – multi-stage cluster sampling	NR	1024	>15	591	FBG OGTT HBA1c	WHO 1999	15.1%	IGT 9.4%	Yes
Collin et al. [23]	1991	Samoa (Apia city – urban Poutasi village – rural Tuasivi village – rural)	CS – population based survey	- 52.0% men, 67.2% women – Apia - 78.8% men 83.9% women – Poutasi - 71.0% men, 83.7% women – Tuasivi	1776	25–74	980	FPG OGTT	WHO 1985	- 9.5% men, 13.4% women – Apia - 5.3% men, 5.6% women – Poutasi - 7.0% men, 7.5% women – Tuasivi	IGT - 5.7% men, 9.7% women – Apia - 7.4% men, 8.0%, women – Poutasi - 3.2% men, 6.0% women – Tuasivi	Yes
Collin et al. [16]	1980–1987	Kiribati Nauru Fiji (Communities)	CS	NR	-204 Nauruans -562 Kiribati Islanders -390 Fiji Melanesians -247 Fiji Indians	>40	100%	FPG OGTT	WHO 1985	- 49.0% Nauruans - 10.0% Kiribati Islanders - 12.3% Fiji Melanesians - 23.1% Fiji Indians	IGT - 14.2% Nauruans - 21.5% Kiribati Islanders - 15.4% Fiji Melanesians - 17.4% Fiji Indians	No
Dowse et al. [24]	1991	PNG (Koki – urban Wanigela – rural Kalo – rural)	CS	-77.2% Koki -88.1%Wanigela -72.5% Kalo	274 Koki 173 Wanigela 50 Kalo	≥25	154 Koki 140 Wanigela 30 Kalo	FPG OGTT	WHO 1985	- 30.3% Koki - 11.7% Wanigela - 1.6% Kalo	IGT -21.0% Koki -17.0% Wanigela -3.0% Kalo	Yes
Durand [29]	2006	FSM (Yap community)	CS	71%	958	≥15	53%	RBS	RBS > 144 or self-reported diabetes	18%	NR	No
Hodge et al. [17]	1991	PNG Nauru (Wanigela and Nauruans communities)	CS – population based survey	- 77% Wanigelas - 86% Nauruans	- 359 Wanigelas - 1041 Nauruans	≥25	-49% Waniglas -53.9% Nauruans	OGTT	WHO 1985	-48.7% Wanigelas -28.9% Nauruans	IGT -28.7% Wanigelas -10.8% Nauruans	No
Khambalia et al. [30]	2004	Nauru	CS – simple random sampling	NR	1592	15–64	792	FPG	FPG ≥ 7.0 mmol/l (diabetes) FPG 6.1–6.9 mmol/l (prediabetes)	13.7% overall (13.0% men and 14.4% women)	6.0% overall prediabetes (6.4% men and 5.5% women)	No
King et al. [19]	1986	PNG (Gamog, Marup and Kaul communities)	CS	-91% Gamog -60% Marup -78% Kaul	-180 Gamog -271 Marup -186 Kaul	≥20	88 Gamog 142 Marup 107 Kaul	FPG OGTT	WHO 1985	-1.8% Gamog -0.7% Marup -0.6% Kaul	IGT -1.2% Gamog -6.8% Marup -1.7% Kaul	Yes
Papoz et al. [25]	1992–1994	New Caledonia (National)	CS	78.3%	9390	30–59	NR	FPG OGTT	WHO 1985	-8.9% overall -15.3% Polynesians -8.4% Melanesians and Europeans	NR	Yes

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Russell-Jones et al. [20]	NR	Fiji (Suva – urban Viti Levu – rural)	CS	NR	302	>40	180	FPG OGTT	WHO 1985	-2.8% male and 11.3% female – Suva -1.2% male and 0.9% female – Viti Levu	IGT -8.6% male and 12.6% female – Suva -2.3% male and 2.8% female – Viti Levu	No
Shmulewitz et al. [28]	1994	FSM (Lelu, Malem, Tafunsek, Utwe and Welung villages)	CS	90%	2188	20–85	58%	FPG OGTT	ADA 1997	12%	NR	No
Taylor et al. [21]	NR	Vanuatu (Vila – urban Nguna – semirural Middle Bush Tanna – rural)	CS	-92% Vila -80–90% Nguna -78% Tanna	-632 Vila -349 Nguna -397 Tanna	≥20	-191 Vila -195 Nguna -232 Tanna	FPG OGTT	WHO 1980	-2.1% men, 12.1% women – Vila -2.1% men, 1.1% women – Nguna -1.0% men, 0.9% women – Tanna	IGT -2.1% men, 3.2% women – Vila -1.8% men, 2.6% women – Nguna -2.6% men, 2.1% women – Tanna	Yes
Taylor et al. [22]	-1980 Fiji -1981 Kiribati -1985 Vanuatu	Fiji Kiribati Vanuatu (rural and urban communities)	CS – cluster sampling	~80–90% in both rural and urban	-2638 Fiji -2938 Kiribati -1366 Vanuatu	≥20	NR	FPG OGTT	WHO 1980	-3.5% male, 7.1% female – urban Fiji Melanesian -1.1% male, 1.2% female – rural Fiji Melanesian -12.9 male, 11.0 female – urban Fiji Indian -12.1 male, 11.3 female – rural Fiji Indian -9.1% male, 8.7% female – urban Kiribati -3.0% male, 3.3% female – rural Kiribati -1.3% male, 2.6% female – urban Vanuatu -2.0% male, 0.0% female – semirural Vanuatu -0.9% male and 0.5% female– rural Vanuatu	NR	Yes
Yamada et al. [64]	2000	Marshall Islands (Ebeye Hospital)	CS – medical records review	NR	692	≥30	NR	FBG RBG OGTT	ADA 1997	20%	IFG 2.5%	No

CS, cross sectional study; FCBG, fasting capillary blood glucose; FBG, fasting blood glucose; OGTT, oral glucose tolerance test; FPG, fasting plasma glucose; RBS, random blood glucose; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; NR, not reported; WHO 1980, the World Health Organisation definition of diabetes in 1980 (2-h post glucose ≥ 11.1 mmol/l) [65]; WHO 1985, the World Health Organisation definition of diabetes in 1985 (FPG ≥ 7.8 mmol/l and/or 2-h post challenge glucose (2-h PG) ≥ 11.1 mmol/l) [66]; WHO 1999, the World Health Organisation definition of diabetes in 1999 (FPG ≥ 7.0 mmol/l and/or 2-h PG ≥ 11.1 mmol/l) [67], and ADA 1997, the American Diabetes Association definition of diabetes in 1997 (FPG ≥ 7.0 mmol/l and/or 2-h PG ≥ 11.1 mmol/l)) [68].

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Table 2 – Prevalence of diabetes in PICTs (WHO STEPS survey reports).

Country	Year of survey	Sample size (*n*)	Age (years)	Diagnosis method/ criteria	Diabetes prevalence %		
					Male	Female	Overall
American Samoa [69]	2004	2072	25–64	FCBG ≥ 6.1 mmol/l	52.3	42.4	47.3
Cook Islands [70]	2003–2004	1870	25–64	FCBG ≥ 6.1 mmol/l	26.1	21.0	23.6
Fiji [71]	2002	2277	25–64	FBG ≥ 6.1 mmol/l	14.6	17.6	16.0
French Polynesia [72]	2010	3469	18–64	FCBG ≥ 6.1 mmol/l	8.4[a]	6.1[a]	7.3[a]
FSM [73]	2002	1638	25–64	FPG ≥ 7.0 mmol/l	26.4	37.1	32.1
Kiribati [74]	2004–2006	1146	25–64	FCBG ≥ 6.1 mmol/l	29.6	26.7	28.1
Marshall Islands [75]	2002	994	15–64	FPG ≥ 7.0 mmol/l	18.9	20.5	19.6
Nauru [76]	2004	501 (15–24 yrs)	15–64	FPG ≥ 7.0 mmol/l	16.1	16.3	16.2 (15–24 yrs)
		382 (25–64 yrs)			NR	NR	22.7 (25–64 yrs)
Niue [77]	2011	863	≥15	FCBG ≥ 6.1 mmol/l	42.1	34.9	38.4
PNG[a] [78]	2007–2008	2944	15–64	FCBG ≥ 6.1 mmol/l	14.7	14.0	14.4
Solomon Islands [79]	2005–2006	950	25–64	FCBG ≥ 6.1 mmol/l	15.3	11.7	13.5
Samoa[a] [80]	2002	2817	25–64	FCBG ≥ 6.1 mmol/l	21.0	23.4	22.1
Tonga [81]	2004	453	25–64	FCBG ≥ 6.1 mmol/l	16.3	16.6	16.4
Tokelau [82]	2005	573	15–64	FCBG ≥ 6.1 mmol/l	35.2	32.2	33.6
Vanuatu [83]	2011	4422	25–64	FCBG ≥ 6.1 mmol/l	21.4	21.0	21.2
Wallis and Futuna[b] [14]	2010	487	25–64	FPG ≥ 7.0 mmol/l	13.6	21.0	17.5

FCBG, fasting capillary blood glucose; FBG, fasting blood glucose; FPG, fasting venous plasma glucose; NR, not reported.
[a] Data from WHO STEPS Survey fact sheet.
[b] Data from study of risk factors for non-communicable diseases in Wallis and Futuna.

3.2. *Risk factors for the development of diabetes*

Eleven cross sectional studies reported on risk factors for the development of diabetes. Additionally, we included diabetes-relevant data from WHO STEPS surveys in 15 countries that reported risk factors for non-communicable diseases more broadly, and collated the results from both sources under the following headings.

3.2.1. *Demographic*

People of Indian origin in Fiji had a significantly higher risk of diabetes than Fijian Melanesians. With regard to gender, females were at greater risk than males for both Fijian Melanesians (OR 1.75, 95% CI 1.30–2.36, $P < 0.001$) and Fijian Indians (OR 1.94, 95% CI 1.33–2.84, $P < 0.001$) [18]. Family history of diabetes was shown to increase the risk of diabetes in Tongans (OR 2.43, 95% CI 1.50–3.93, $P < 0.001$) [27] and Samoans [23]. The risk of developing diabetes was also shown to increase with age [18,23,27,28].

3.2.2. *Lifestyle*

The prevalence of physical inactivity (<600 MET-minute/ week) was substantial and over half of the adult population in most PICTs were physically inactive [15]. More than 80% of Polynesian and Micronesian populations in American Samoa, Cook Islands, Kiribati, Marshall Islands, Nauru and Tokelau consumed too few fruits and vegetables (less than 5 servings of fruits and vegetables per day) [15]. Studies in Polynesians and Micronesians showed that diabetes was associated with physical inactivity [23] and urban dwellers were less physically active than their rural counterparts [22].

3.2.3. *Physical*

Body mass index (BMI) varied widely across the available studies. High mean BMI and high prevalence of overweight and obesity were reported in many studies [16,20,22,25,27,29,30]. In most PICTs, mean BMI of urban dwellers were higher than their rural counterparts [20,22]. BMI and waist-to-hip ratio were associated with diabetes among Polynesians and Micronesians [23,27,30]. The prevalence of the adult population with overweight (BMI ≥ 25 kg/m^2) was over 90% and obesity (BMI ≥ 30 kg/m^2) was over 70% in countries such as American Samoa, Tokelau and Nauru [15]. The prevalence of hypertension (systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg or currently on hypertension medication) in adults was substantial. For example, approximately 30% in American Samoa and Cook Islands had hypertension [15].

3.2.4. *Biochemical*

High total cholesterol, triglycerides and LDL levels were found in many studies [17,20,21,28]. Mean plasma cholesterol level was higher in urban dwellers than their rural counterparts [20,21]. High cholesterol level showed significant association with diabetes and pre-diabetes in a study among Nauruans [30]. WHO reported that over 70% of adult population in Cook Islands had high total cholesterol (≥5.0 mmol/l) and approximately 50% in Tonga and FSM [15].

3.3. *Complications*

Table 3 shows the prevalence of diabetes complications in subjects with diabetes. Seven of the included articles were cross sectional, two studies were cohort and one study was longitudinal. Of the 10 studies, eight reported the relationship between complications of diabetes and risk factors for complications.

3.3.1. *Risk factors for developing diabetes complications*

The prevalence of risk factors for developing diabetes complications was substantial in people with diabetes. For

Table 3 – Complications of diabetes in PICTs.

Author and year	Year of survey	Country (sample site)	Study design	Sample size (known diabetes)	Age (years)	Mean duration of diabetes (years)	Complications	Incidence and/or prevalence (%)	The relationships between complications and risk factors (OR/X^2/RR)	Method of assessment or source of data
Abidi et al. [84]	1982–2002	CNMI (Commonwealth Health Centre)	Longitudinal	180[a]	NR	NR	Renal	- Of the 180 new cases of ESRD treated, 137 (76%) were due to diabetes - The point prevalence of diabetic ESRD was 238 cases per 100,000 total population	NR	A registry/records of all persons initiating chronic renal replacement therapy
Franzco et al. [32]	2009	Fiji (Viti Levu Island)	CS – multistage cluster random sampling	222 (424 eyes only)	≥40	NR	Eye	- 1.2% had proliferative retinopathy - 7.6% had active significant maculopathy	Diabetic eye disease was associated with time since diagnosis. <5 years vs 5–10 years OR 2.41 (95% CI, $P = 0.03$), <5 years vs >10 years OR 8.13 (95% CI, $P < 0.001$)	Visual acuity, Ophthalmoscope
Brooks et al. [33]	NR	Fiji (Viti Levu Island)	Cohort	446	41–68	5	Eye Renal	- 52.6% Fijian had retinopathy - 59% with retinopathy had albuminuria - 49% without retinopathy had albuminuria	Retinopathy was significantly associated with longer duration of diabetes	Direct Fundoscopy, spot urine albumin by Micral-Test II
Collin et al. [34]	1991	Samoa (one urban and two rural)	CS	204	25–74	NR	Eye Renal	- 43.2% had retinopathy among known diabetes - 15.4% had retinopathy in newly diagnosed diabetes - 23.4% had elevated UAC among known diabetes - 26.0% had elevated UAC among newly diagnosed diabetes	- Diabetes retinopathy was associated with duration of diabetes (OR 43 in 10–19 years, $P < 0.001$), FPG (OR 7.8 in poor glycaemia control, $P = 0.011$) and BMI (OR 0.91 for BMI +1 kg/m^2, $P = 0.008$) - Elevated UAC was associated with duration of diabetes (OR 5.9 in 10–19 years, $P = 0.009$) and serum triglyceride concentrations (OR 1.9 for triglycerides + 1 mmol/l, $P = 0.023$)	Visual acuity retina photograph radio-immunoassay for UAC

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Table 3 (*Continued*)

Author and year	Year of survey	Country (sample site)	Study design	Sample size (known diabetes)	Age (years)	Mean duration of diabetes (years)	Complications	Incidence and/or prevalence (%)	The relationships between complications and risk factors (OR/X^2/RR)	Method of assessment or source of data
Erasmus and Okesina [35]	NR	PNG (Ports Moresby)	Prospective	71	41.1 (mean)	2.8	Renal	- 42% had mircoalbuminuria	Microalbuminuria was associated with sex (X^2 7.36, P = 007) and hypertension (X^2 8.79, P = 003)	Immuno-trubidimetric assay
Falconer et al. [37]	2006	Vanuatu (Port Vila)	CS – convenience sampling	172	27–73	8	Eye Renal Limb	- 34% reported eye problems - 13% reported renal impairment - 6% reported foot and leg ulcers - 4% reported lower extremity amputations	NR	Self reported
Hodge et al. [17]	1991	PNG Nauru (Wanigela and Nauruans communities)	CS	NR	≥25	NR	Renal	- 80.6% of Nauruans and 40.5% of Wanigelas had either micro-macroalbuminuria	- Worsening glucose tolerance was associated with increasing prevalence of micro- and macroalbuminuria	Albumin measurement in random or early morning urine specimens
Humphrey et al. [36]	1982–1994	Nauru (Nauru hospital)	Cohort	375	≥25	NR	Limb	- All nontraumatic amputees (46 subjects) had diabetes - The incidence of first lower extremity amputations in type 2 diabetes was 8.1 per 1000 person-years in this study and estimated 7.6 per 1000 person-years nationally	FPG (1 mmol/l) (RR 1.26, $P < 0.001$) and diabetes duration (1 year) (1.15 RR, $P < 0.001$) were independent risk factors for amputation	Hospital operating theatre record
Pinhey et al. [31]	1991	Guam	CS – stratified random sampling	52	≥30	NR	CVD	- 36% men and 9% women reported heart attack - 9% men and 19% women reported stroke	- Men with diabetes were significantly more likely to suffer heart attack than men without diabetes - Women with diabetes were significantly more likely to have stroke than women without diabetes	Self reported

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example, the prevalence of overweight in Melanesians and Micronesians was between 78% and 90%, obesity was between 33% and 53% and hypertension was between 31% and 72% [3,31]. Diabetic retinopathy was independently associated with increased duration of diabetes [3,32–34], poor glycaemic control, and raised BMI [34]. Elevated urinary albumin concentration was independently associated with duration of diabetes and serum triglyceride concentration [34]. Microalbuminuria was associated with hypertension [3,35], increased duration of diabetes and poor glycaemic control [3]. Two studies indicated that poor glycaemic control and increased diabetes duration were independent risk factors for amputation [36] and abnormal foot sensation [3].

3.3.2. *Microvascular complications*

Wide variations in the prevalence of diabetes complications were reported. For example, the prevalence of retinopathy ranged from 69% in Nauru [3] to less than 10% in Fiji [32]. The prevalence of microalbuminuria varied widely; 71% in Nauru, 51% in Vanuatu, 42% in PNG and 36% in the Solomon Islands [3,35]. The prevalence of abnormal foot sensation was 30% and abnormal digital foot pulse was 24% in Nauru [3], and foot ulcer and diabetes related amputation rates were approximately 5–10% [3,37]. The incidence of first lower extremity amputations in Nauruans aged ≥25 years with type 2 diabetes was 8.1 per 1000 person-years in the study cohort and estimated 7.6 per 1000 person-years nationally [36].

3.3.3. *Macrovascular complications*

Little data were available in relation to macrovascular complications. A study in Guam reported that 36% men and 9% women with diabetes had a heart attack and 9% men and 19% women had a stroke [31]. Men with diabetes were significantly more likely to suffer heart attack whereas women were more likely to suffer stroke than their counterparts without diabetes [31].

3.4. *Mortality*

Two studies reported on diabetes mortality. A longitudinal study in Tonga found that diabetes was the second leading cause of death in adult males (19%) and the third in females (18%) [38]. Diabetes related death was more common in adult Fijian Indians (11.1%) than Fijian Melanesians (2%) [39]. WHO estimated that the proportion of deaths attributed to diabetes (% of total deaths, all ages) in PICTs ranged from 2% in PNG to 8% in Kiribati [12,13].

3.5. *Diabetes care*

Table 4 summarises the results of seven articles that reported on diabetes care i.e. receiving medical checkups, achieving clinical targets, capacity to deliver diabetes services, awareness and education. Studies from Melanesians and Micronesians reported low preventive care [40], and poor blood pressure, glycaemic and lipids control [3,41]. Similarly, four studies of Melanesians and Micronesians showed low diabetes awareness and education among

Win Tin et al. [3]	NR	Nauru Solomon Islands Vanuatu (National Diabetes Centres)	CS – convenience sampling	495	51.2 (mean)	8	Eye Renal Limb	In Nauru, the Solomon Islands and Vanuatu, - 69%, 40% and 42% had retinopathy respectively - 71%, 36% and 51% had microalbuminuria respectively - 30%, 23% and 19% had abnormal foot sensation respectively - 24%, 18%, 1.5% had abnormal digital foot pulse respectively - 8%, 8% and 5% had foot ulcer respectively - 11% had diabetes related amputation in each country - 42%, 55% and 72% had hypertension respectively	- Diabetic retinopathy was significantly associated with longer duration of diabetes - Microalbuminuria was significantly associated with longer duration of diabetes, hypertension and poorer glycaemia control - Abnormal foot sensation was significantly associated with longer duration of diabetes and poor glycaemic control	Eye – by fundus examination through dilated pupils Microalbuminuria – by DCA Analyser Foot sensation – by 10 g microfilament

NR, not reported; CS, cross sectional study; OR, odd ratio; RR, relative risk; X^2, Chi-square test; FPG, fasting plasma glucose; ESRD, end stage renal disease; CVS, cardiovascular diseases, UAC, urinary albumin concentration.

[a] All new ESRD patients with or without diabetes.

Table 4 – Diabetes care in PICTs.

Author/year	Year of survey	Country (sample site)	Study design	Sample size – subjects with diabetes	Age (years)		Diabetes care
Suguitan and McDuffie, 2005 [40]	2001–2003	Guam (National)	CS – data from Guam BRFSS	2484	≥18	Receiving medical checkups	The percentages of people with diabetes in Guam were below all four US national targets for diabetes related preventive care - 65.6% reported having annual eye examination - 70.4% reported having annual foot examination - 32.2% reported performing self monitoring of blood glucose - 56.7% reported having their HbA1c measured at least twice annually
Win Tin et al. 2014 [3]	NR	Nauru Solomon Islands Vanuatu (Diabetes Centres)	CS – convenience sampling	459	54 (mean)	Achieving clinical targets	In Nauru, the Solomon Islands and Vanuatu, - 50%,31% and 15% achieved clinical target for blood pressure control respectively - 20%, 17% and 28% achieved clinical target for glycaemic control (HbA1c) respectively - 47%, 55% and 49% achieved clinical target for total cholesterol level respectively
Erasmus and Sinha 1995 [41]	1989–1990	PNG (Ports Moresby Diabetes Clinic)	Prospective	83	47 (mean)	Achieving clinical targets	- 53 subjects (64%) had poor glycaemic control (mean HbA1c > 10%) - Among 19 newly diagnosed subjects, metabolic control improved only in 2 (11%) subjects and worsened in another 2 (11%) Subjects
David et al. 2010 [43]	NR	Guam (Community health centres)	CS	125	13–84	Awareness and education	- 40% were not aware of the type of diabetes they had - 20% did not receive diabetes self management education - 30–60% did not receive nutritional counselling and complications screening - Approximately 50% generally satisfied quality of services
Kuruvatti and Price 2002 [42]	NR	Fiji (Viti Leu Island)	CS	78	57.4 (mean)	Awareness and education	- 24.4% failed to name a complication. The most well known complications were blindness 43.6%, foot sepsis 37.2%, cardiovascular complications 35.9% and renal failure 24.4% - 60.3% did not know the cause of diabetes, 12.8% thought overeating and 12.8% thought too much sugar in the diet could lead to diabetes
Qoqonokana et al. 2010 [44]	2009	Solomon Islands (eye clinic of national referral hospital)	CS	50	≥20	Awareness and education	- 66% aware of diabetic foot complication - 88% aware of eye complication - 58% aware that prevention of eye complication linked to diet and blood sugar, exercise 10%, regular check up 8% and drug compliance 4% - 32% understood that diabetic eye disease can be treated
Win Tin et al. 2013 [45]	NR	Nauru Solomon Islands Vanuatu (Diabetes Centres)	CS – convenience sampling	85	33–90	Awareness and education	- 36% did not received foot care information prior to the amputation - 19% did not attend anywhere for regular treatment The major reasons leading to amputations were - Delayed treatment (42%) - Use of traditional treatment (18%) - Insufficient knowledge about foot care (11%)

BRFSS, Behavioural Risk Factor Surveillance System; CS, cross sectional study; NR, not reported.

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people with diabetes [42–45]. Another study from PNG reported deficiencies in quality of care such as the limited number of health professionals specifically trained in diabetes and equipment for testing HbA1c [46].

3.6. *Quality of life*

Two cross sectional studies reported on quality of life. The average quality of life among people with diabetes in Vanuatu was relatively high at 91/100 (range 37–100) on the EQ-5D visual analogue scale [37] and 18% of participants reported suffering anxiety or depression [37]. People with diabetes were significantly more likely than people without diabetes to be impoverished and were more likely to assess their own physical health as poor [31]. The same study found that men with diabetes were significantly more likely than men without diabetes not to have graduated from high school and to be unemployed [31].

3.7. *Financial cost of diabetes*

A study in Vanuatu found that, over the year preceding the study, health system costs for 2352 outpatient visits totalled 4020 USD; 140 overnight hospital stays cost 12,580 USD; and prescription medications cost 29 USD/person. Of 172 people with diabetes surveyed, 31 (18%) reported that their average out-of-pocket expenses for over-the counter medications was 60 USD/person/year, 110 (64%) reported that their average cost for transport was 18 USD/person/year and 38 (22%) reported that their average cost for special diet was 332 USD/person/year ($332 USD) [37].

4. Discussion

This review identified several important findings about the prevalence of diabetes, its complications, and the quality of diabetes care in PICTs. Overall, the prevalence of diabetes in PICTs is higher than that reported for Asia, Africa and the Middle East [7–9], and also higher than the average diabetes prevalence in the Western Pacific Region [2,11].

As with the international evidence [2], the prevalence of diabetes in PICTs increased with age and the current demographic trend to an ageing population will almost certainly accelerate further increases in diabetes prevalence. Ageing aside, there is little doubt that the high prevalence of risk factors for the development of diabetes in PICTs is closely related to rapid economic and urban development over recent decades and the concomitant rise in energy dense diets and sedentary work and leisure behaviour [4,10,15]. This is corroborated by the finding that the prevalence of diabetes was considerably higher in urban dwellers than in their rural counterparts [20–24], arguably due to less sedentary behaviour in rural areas and greater access to western diets in urban areas. These influences will almost certainly intensify and lead to further increases in diabetes prevalence unless preventative action is taken and this highlights the need for increased attention to primary prevention programmes on a national basis as well as specifically targeting urban dwellers.

Overall, the prevalence of diabetes complications in PICTs is higher than that reported for other regions e.g. Asia, Africa and the Middle East [7–9]. This is undoubtedly an important factor in driving the high rates of diabetes related mortality reported in PICTs [12,13,28]. However, the prevalence of risk factors for, and complications of diabetes varied widely across countries and it was not possible from our review to determine the relative contribution of methodological differences across studies, genetic factors, and exposure to risks such as sedentariness and western diets to these results.

Some of the studies in our review indicated deficiencies in the quality of diabetes care available in PICTs [3,40,41] and this is reflected in other studies and reports [47–49]. The issues centre around the lack of critical mass of human resources including numbers, distribution training and skills deficits, and lack of access to specialist expertise; lack of equipment and inadequate and uncertain supply chains for medications and diagnostics; low emphasis on public and patient awareness of diabetes and inadequate attention to patient self-care education [3,40,41,43]. A recent study in Tonga found high levels of morbidity and mortality associated with diabetes and highlighted the need to provide better diabetes care [50]. Without effective interventions, premature deaths and morbidity resulting from diabetes and its complications will continue to take a heavy toll on human suffering and, at a macro-economic level, on human capital, productivity and economic development and poverty reduction.

There is ample evidence proving the effectiveness of lifestyle interventions for prevention and control of diabetes in both developed and developing economies [51–53]. There is equally convincing evidence of effective drug therapies and processes of care for preventing and delaying the onset of diabetes complications [54–56] and patient education has been shown to lead to improved processes and outcomes.

Unfortunately, very little of this evidence appears to have been translated into policy and practice in PICTs. While lack of resources and technical expertise in PICT health systems play a role, even within existing resources there is room for improvement in most PICTs but this has historically been hampered by some key factors. One factor has been a lack of political commitment among PICT governments to act decisively on diabetes and related chronic disease prevention and control. Another is the influence of trade with wealthy developed economies such as Australia, New Zealand and the US – particularly in unhealthy food and beverages. Yet another is the complete absence in some cases and fledgeling nature in others, of consumer diabetes associations to advocate for improved services and policy change. Perhaps most importantly, the health component of international aid to the developing world has traditionally been disproportionately dedicated to the control and eradication of infectious diseases. This is remarkable given that over 60% of mortality globally and 75% in PICTs is attributable to NCDs [57] and continues despite the recent and strong UN and WHO focus on diabetes and related NCDs [58–60].

This review provides ample evidence of the urgent need to intervene to improve the quality, accessibility and effectiveness of diabetes prevention and care in PICTs. However, it should be noted that there are deficiencies in the available evidence. For example, despite anecdotal

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reports of type 1 diabetes and gestational diabetes, our formal literature search yielded no peer-reviewed articles reporting specifically on either of these conditions that met the inclusion criteria. Although there were technical reports of the financial burden of NCDs [61,62], we found only one peer-reviewed article that reported specifically on the financial cost of diabetes [37].

The review was also limited by the quality of the available evidence. Most of the included studies were cross-sectional and there were few longitudinal studies to enable attribution of causality or associations, or to monitor diabetes trends over time. Many of the available prevalence studies were undertaken up to 20 years ago or more and therefore unlikely to reflect current diabetes rates. Studies used different methodology, diagnostic criteria and sample size. Consequently, the prevalence data were not readily comparable. It is also difficult to compare and interpret the wide variations in diabetes complications across studies, countries and ethnic groupings as there were differences in the methods used for diagnosing complications as well as in the ages of the study populations.

Nonetheless, this review provides an overview of the available evidence on the epidemiology, health, social, and economic impacts of diabetes, and the status of diabetes care in PICTs. It highlights the burden of diabetes in PICTs and the urgent need for more intensive and effective response. This review also draws attention to important knowledge deficits in the literature. For example, studies of type 1 diabetes, gestational diabetes, and costing studies are urgently needed to inform health care policy and planning and service delivery. More comprehensive research using standardised criteria for diagnosing diabetes and its complications is also needed to monitor secular trends in diabetes, assess its the financial costs, and evaluate the effectiveness of interventions.

Conflict of interest

None known or perceived.

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